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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: August 9, 1977

Project Title: Vogtle Nuclear Plant Hydraulic Model Studies.

Project No: E-20-619

Project Director: Dr. P. G. Mayer

Sponsor: Southern Company Services, Inc.

Agreement Period: From 8/4/77 Until 12/4/77

Type Agreement: Standard Industrial Research Agreement dated 8/4/77

Amount: $35,770

Reports Required: Interim Reports, Project Completion Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. G. B. Dougherty, Manager
Hydro Projects Department
Southern Company Services, Inc.
P. O. Box 2625
Birmingham, AL 35202

Defense Priority Rating: N/A

Assigned to: Civil Engineering (School/Laboratory)

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CA-3 (3/76)

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OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 1/16/79

Project Title: Vogtle Nuclear Plant Hydraulic Model Studies

Project No: E-20-619

TERMINATED

Project Director: Dr. P. G. Mayer

Sponsor: Southern Company Services

Effective Termination Date: 1/15/79

Clearance of Accounting Charges: 1/15/79

Grant/Contract Closeout Actions Remaining:

- x Final Invoice ~~and Closing Documents~~
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ____________________

Assigned to: Civil Engineering (School/Laboratory)

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Other ____________________

CA-4 (3/76)

E-20-619

VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

Report No. 1: Construction and Test Results, 1:25 Scale Model

by

Paul G. Mayer

Project No. E-20-619
Southern Company Services
Birmingham, Alabama

September, 1977

SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

HOOL OF
ENGINEERING

TELEPHONE:
(404) 894 2225

September 16, 1977

Mr. G. B. Dougherty, Manager
Hydro Projects Department
Southern Company Services
P.O. Box 2625
Birmingham, Alabama 35202

Subject: Vogtle Nuclear Plant Hydraulic Model Studies
Report No. 1: Construction and Test Results,
1:25 Scale Model

Dear Mr. Dougherty:

Attached please find my report on the construction and operation of the 1:25 scale hydraulic model of the cooling water circulating system. The model consisted of a facsimile of the cooling tower basin, and geometrical models of the return channel and of the circulating water pump intake structure.

The report also includes the results of tests conducted on the 1:25 scale model. The tests established pertinent flow patterns in the curved trapezoidal return channel. The test results are presented both in tables and in graphs.

Sincerely,

Paul G. Mayer
Regents' Professor

PGM/ln

Attachment

cc: J. M. Hire, Jr.
J. E. Fitzgerald
J. W. Wilson

VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

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Birmingham, Alabama

September, 1977

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VOGTLE NUCLEAR PLANT HYDRAULIC
MODEL STUDIES

Report No. 1: Construction and Test Results,
1:25 Scale Model

I. Introduction

The purpose of hydraulic model studies is to verify the design and the hydraulic performance of the cooling water pump intake structure for Unit No. 1 of the proposed Alvin W. Vogtle Nuclear Power Plant of the Georgia Power Company

This report is to summarize the work to date which consisted of the construction and operation of a 1:25 scale model. Test results are included.

II. The 1:25 Scale Hydraulic Model

In the proposed Vogtle Nuclear Plant, the cooling water is to circulate from a cooling tower (Unit No. 1) through an open channel into a pump intake structure. Two centrifugal pumps then force the cooling water through the condensers and back into the cooling tower.

The ring foundation of the cooling tower is some 456 feet in diameter. The foundation extends above the proposed water level and, thus, serves as a collecting basin under the tower. A 200-foot long rectangular opening in the ring wall perimeter provides for an outflow into the return channel. The lip elevation of the outflow opening is at 210.5 feet MSL.

From the opening at the cooling tower a transition converges the flow into a curved trapezoidal channel. The trapezoidal cross section consists of a 12-foot wide horizontal bottom and side slopes of one on two (1:2). The horizontal alignment of the return channel consists of a compound curve. The various radii and subtended angles are as submitted by Dr. Chiou on August 12, 1977, and are shown in Figure 1. After the curved channel, a transition guides the flow into the pump intake structure.

The pump intake structure consists of three bays as shown in Figure 2. Each of the two circulating water pumps occupy a 20-foot wide bay. A third bay of 14-foot width is provided for two turbine cooling pumps.

In the 1:25 scale hydraulic model the cooling tower was simulated by a rectangular wooden box the length of which corresponded to the cord length associated with a 200-foot long arc along the tower perimeter. The channel transitions were made of 1/2 inch plywood and consisted of two intersecting plane surfaces, one of which was slanted at a side slope of 1:2, and the other was vertical. The curved trapezoidal channel sections were also made of 1/2-inch plywood and consisted of articulated channel linings supported on vertical templets. An appropriately scaled intake structure was mounted at the terminal end of the trapezoidal return channel and transition. Figure 3 shows an elevation view of the proposed pump intake structure. Figure 4 shows an oblique view of the model in the laboratory.

The dynamical similarity between model and prototype operations was based on the Froude Law. Accordingly, all physical dimensions of the model were 1/25 of the prototype dimensions. The velocity scale and the time scale were equal to the square-root of the length scale, or 1/5 of the prototype velocities and 1/5 of the prototype times. Finally, the ratio of the appropriate discharge rates were obtained from the 5/2-power of the length scale. A summary of the Froude relationships is given below:

Table 1. Froude Relationships
1:25 Scale Model

	Length	Velocity	Time	Discharge
Model	1	1	1	1
Prototype	25	5	5	3125

In the model, the cooling water pumps were simulated by two horizontally mounted centrifugal pumps. Each pumped water from its bay through an appropriate replica of the circulating water pump bell. A flow control valve was located at each pump. The water was returned to the "cooling tower" head box through 2-inch PVC pipes. Each line had a calibrated elbow meter connected to a differential manometer to monitor the flow rates. The return lines had submerged directional nozzles (90° elbows) to obtain reasonably uniform outflows from the head box. Figure 5 shows a close-up of the model intake structure including suction bells, pumps, control valves and return lines. Water surface elevations were determined by means of calibrated staff gages. The elevations of key points along the model floor were set accurately by means of an engineer's level. The turbine cooling water pump bay was modeled, but the turbine cooling water pumps were not modeled since the associated flow rates were quite small relative to the circulating water pump flow rates.

III. Test Procedures and Results

The purposes of the 1:25 scale model were largely to establish the nature of the flow patterns resulting from the curved channel alignment and to pre-establish an understanding of flow patterns which need to be simulated in the 1:8 scale model of the pump intake structure.

As a first step, the directional nozzles on the terminal ends of the return lines were adjusted (rotated to yield approximately uniform inflow conditions across the cooling tower opening). The model circulating water pump discharges were then set to simulate plant flows. The depth of water at the intake was set to correspond to prototype elevations between the high water of 215 feet and the low water of 212 feet. For each test condition, velocities were measured at various stations along the channel by means of a calibrated midget current meter. Figure 6 shows the measuring stations in the 1:25 scale model. The test results are summarized in Tables 2, 3 and 4. Graphical displays of the velocities in the return channels are given in Figures 7, 8 and 9.

In order to further define the flow patterns near the intake structure, velocities were measured at three additional stations within the channel transition and at two different depths. The location of the near-intake velocity measurements are shown on Figure 10. In these tests, both circulating water pumps were operated at a combined flow rate of 1110 cfs. In one series, the water surface elevation at the pump intake structure elevation was maintained at 212 feet and in the other series at 215 feet (MSL). The test results are summarized in Tables 5 and 6. The results are graphed in Figures 11 and 12.

After an analysis of results from the above tests, additional information on velocity distributions near the pump intake structure was obtained for the condition of only one circulating water pump in operation. Alternately, both the pump in the center bay and the pump in the north bay were operated at 560 cfs, the water levels were maintained at the elevation of 213 feet. and velocities were again measured in the channel transition. The test results are summarized in Tables 7 and 8, and they are shown graphically in Figures 13 and 14.

The flows throughout the return channel were generally subcritical. A notable exception existed during the test sequence with the pump intake water surface at elevation 212 feet (minimum water level). During this test the flows at the cooling tower head bay were slightly supercritical. A consequence of this condition would be a shift of the flow control from the circulating water pumps to a weir condition at the cooling tower with the possibilities of reducing the pump bell submergence and interference with the performance of the circulating water pumps.

IV. Conclusions and Recommendations

The flow patterns in the 1:25 scale model of the return channel indicated that:

a. the alignment proposed by Dr. Chiou in his sketch dated 8/12/77 yields satisfactory and nearly uniform flow conditions in the channel area near the pump intake structure.

b. at the minimum water level of 212 feet at the intake structure, the flow at the other end at the "cooling tower" head box was slightly supercritical. At the higher water surface elevations the flow in the entire return channel was subcritical.

c. No seriously adverse flow conditions were observed within the pump intake structure under any of the test conditions.

As a consequence of the above findings, it is recommended that:

d. the alignment of the tested return channel is adopted (Chiou 8/12/77) in preference to the alignment shown in the Bechtel Drawing No. Sk, 4-5014.

e. an adherence to the Bechtel channel alignment (the Bechtel alignment was only communicated on August 31, 1977) would require a rebuilding of the 1:25 scale model and a test program similar to the one presently reported.

f. the proposed lowering of the intake structure floor from elevation 195.67 feet to an approximate elevation of 190 feet (oral communication during Laboratory conference between Southern Service personnel and the principal investigator on August 31, 1977) will not necessitate a rebuilding and retesting program. This proposed modification is judged to further improve flow patterns near the intake structure, and it will increase the submergence of the pump suction bell, thus, enhancing conditions favoring satisfactory performances of the circulating water pumps

g. the length of the opening in the cooling tower ring wall should be increased to assure subcritical flow conditions at all times. The length of the opening should also be increased to accommodate the proposed piers (numbers, shapes and spacings are not known at this time).

h. the 1:8 scale model can be built with a straight approach channel, and the appropriate velocity distribution can be modeled to reflect the flow patterns due to the curved channel in the prototype.

i. since there is still some uncertainty regarding the alignment of the return channel, the straight approach channel in the 1:8 scale model can always be "tuned" to reflect the effects of the channel curvature. The information for this "tuning" can be obtained from the 1:25 scale model which will be kept operational for this purpose throughout the duration of the project.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 2. Velocities in Approach Channel in 1:25 Scale Model

Model Station(*)	Prototype Velocities ft/sec(**)	Direction	Comments(***)
0a	0.6	30°R	Very slow, some reversed flow
0b	1.7	Downstream	
0c	1.9	50°L	
0d	0.8	Downstream	
0e	0.7	45°L	
0f	0.5	100°R	Reversed flow
0g	0.5	45°L	
1a	1.4	Downstream	
1b	0.8	Downstream	
1c	0.4	30°L	
1d	0.1	10°L	
1e	0.2	Downstream	
1f	0.1	45°L	Average direction-very dispersed
1g	0.1	50°L	
1h	0.1	45°L	
1i	0.8	45°L	
2a	1.6	45°R	
2b	1.5	30°R	
2c	0.8	Downstream	
3a	0.5	Downstream	Somewhat dispersed
3b	1.4	Downstream	
3c	1.1	Downstream	
4a	0.6	Downstream	
4b	1.2	Downstream	
4c	1.2	Downstream	
5a	0.2		Very slow flow
5b	1.1	Downstream	
5c	1.4	Downstream	

(*) See definition sketch
(**) Velocities were measured at an equivalent depth of four feet beneath the water surface.
(***) Water surface elevation at Cooling Tower Weir - 215.3 ft.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 3. Velocites in Approach Channel in 1:25 Scale Model

Model Station(*)	Prototype Velocities ft/sec(**)	Direction	Comments(***)
0a	1.4	N/A	These all are directed in the downstream direction, but exhibit unsteady behavior
0b	1.0	N/A	
0c	2.2	N/A	
0d	1.8	N/A	
0e	1.1	N/A	
0f	0.8	N/A	
0g	1.1	N/A	
1a	1.9	5°R	
1b	0.8	Downstream	
1c	0.6	Downstream	These also exhibit unsteady behavior, but generally move downstream
1d	0.7	Downstream	
1e	0.4	N/A	
1f	0.6	N/A	
1g	0.6	N/A	
1h	0.4	N/A	
1i	1.6	15°L	
2a	2.0	15°R	
2b	1.5	Downstream	
2c	1.6	Downstream	
3a	0.7	Downstream	Unsteady
3b	1.6	Downstream	
3c	1.5	5°L	
4a	0.9	Downstream	
4b	1.5	Downstream	
4c	1.4	Downstream	
5a	0.0	N/A	
5b	1.1	Downstream	
5c	1.5	Downstream	

(*) See definition sketch.
(**) Velocities were measured at an equivalent depth of two feet beneath the water surface.
(***) Water surface elevation at Pump Intake Station - 213.0 ft.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 4. Velocities in Approach Channel in 1:25 Scale Model

Model Station(*)	Prototype Velocities ft/sec(**)	Direction	Comments
0a	1.2	N/A	Unsteady
0b	1.4	N/A	"
0c	2.4	N/A	"
0d	1.7	N/A	"
0e	0.9	N/A	"
0f	0.9	N/A	"
0g	1.2	N/A	"
1a	1.1	5°R	
1b	0.6	Downstream	
1c	0.6	Downstream	
1d	0.3	Downstream	
1e	0.2	N/A	Unsteady
1f	0.4	N/A	"
1g	0.2	5°L	
1h	0.4	5°L	
1i	1.0	10°L	
2a	1.4	20°R	Unsteady
2b	1.4	Downstream	
2c	1.1	Downstream	
3a	0.6	Downstream	
3b	1.4	Downstream	
3c	1.1	Downstream	
4a	0.6	Downstream	
4b	1.3	Downstream	
4c	1.1	Downstream	
5a	0.0	N/A	Reversed, unsteady
5b	1.1	Downstream	
5c	1.3	Downstream	

(*) See definition sketch
(**) Velocities were measured at an equivalent depth of two feet beneath the water surface.
(***) Water surface elevation at Pump Intake Station - 215.0 ft.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 5. Velocities in Approach Channel
in 1:25 Scale Model

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments(**)
42a	0.4	15°R	Velocities were measured at an equivalent depth of two feet beneath the water surface.
42b	1.2	Downstream	
42c	1.6	5°R	
42d	1.9	Downstream	
42e	1.9	Downstream	
44a	0.2	N/A	Unsteady, generally upstream
44b	0.6	Downstream	
44c	1.3	Downstream	
44d	1.6	Downstream	
44e	1.5	Sownstream	
46a	0.2	N/A	Unsteady, no general pattern
46b	0.4	Downstream	
46c	1.1	Downstream	
46d	1.4	Downstream	
46e	1.1	Downstream	
42a	N/A		Velocities were measured at an equivalent depth of 11 feet beneath the water surface.
42b	N/A		
43c	1.7	Downstream	
43d	N/A		
43e	N/A		
44a	N/A		
44b	1.2	Downstream	
44c	1.6	Downstream	
44d	1.8	Downstream	
44e	N/A		
46a	0.3	N/A	Unsteady, no general pattern
46b	1.1	Downstream	
46c	1.7	Downstream	
46d	1.6	Downstream	
46e	1.7	Downstream	

Note: N/A indicates current velocities or directions too low for accurate measurement.

(*) See definition sketch

(**) Water surface elevation at Pump Intake Station - 212.0 ft

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 6. Velocities in Approach Channel in 1:25 Scale Model

Model Station(*)	Prototype Velocities ft/sec	Direction	Comment(**)
42a	0.4	20°R	Velocities were measured at an equivalen depth of two feet beneath the water surface
42b	0.8	Downstream	
42c	1.2	Downstream	
42d	1.4	5°R	
42e	1.2	5°R	
44a	0.0	N/A	Unsteady, generally upstream
44b	0.6	Downstream	
44c	1.1	Downstream	
44d	1.2	Downstream	
44e	0.9	Downstream	
46a	0.2	N/A	Unsteady, pronounced eddy
46b	0.4	Downstream	
46c	0.9	Downstream	
46d	1.2	Downstream	
46e	0.9	Downstream	
42a	N/A		Velocities were measured at an equivalent depth of 11 feet beneath the water surface.
42b	N/A		
42c	1.3	5°R	
42d	N/A		
42e	N/A		
44a	N/A		
44b	0.9	Downstream	
44c	1.2	Downstream	
44d	1.4	5°R	
44e	N/A		
46a	0.0	N/A	Unsteady, eddy pattern
46b	0.8	Downstream	
46c	1.3	Downstream	
46d	1.3	Downstream	
46e	1.2	Downstream	

Note: N/A indicates current velocities or directions too low for accurate measurement

(*) See definition sketch

(**) Water surface level at Pump Intake Station - 215.0 ft.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 7. Velocities in Approach Channel
in 1:25 Scale Model
Center Bay Pump Only

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
			The following are taken at an equivalent depth of 2 ft.
42a	0.0	N/A	Dispersive, very slow
42b	0.0	Downstream	
42c	0.6	Downstream	
42d	0.6	Downstream	
42e	0.5	Downstream	
44a	0.0	N/A	
44b	0.1	Downstream	Dispersive
44c	0.5	Downstream	
44d	0.6	Downstream	
44e	0.1	Downstream	
46a	0.0	N/A	Dispersive
46b	0.4	Downstream	
46c	0.7	Downstream	
46d	0.2	5°L	
46e	0.0	N/A	Dispersive
			The following are taken at an equivalent depth of 11 ft.
42a	N/A	N/A	
42b	N/A	N/A	
42c	0.7	Downstream	
42d	N/A	N/A	
42e	N/A	N/A	
44a	N/A	N/A	
44b	0.3	Downstream	
44c	0.8	Downstream	
44d	0.8	Downstream	
44e	N/A	N/A	
46a	0.0	45°R	
46b	0.6	Downstream	
46c	0.9	Downstream	
46d	0.7	45°L	
46e	0.3	N/A	Erratic

(*) See definition sketch
(**) Water surface elevation at Pump Intake Station - 213.0 ft.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 8. Velocities in Approach Channel in 1:25 Scale Model North Bay Pump Only

Model Station(*)	Prototype Velocities ft/sec.	Direction	Comments(**)
			The following are taken at an equivalent depth of 2 ft.
42a	0.0	N/A	Dispersive
42b	0.0	Downstream	Very slow
42c	0.7	Downstream	
42d	0.9	Downstream	
42e	1.1	Downstream	
44a	0.1	N/A	Dispersive
44b	0.2	N/A	Dispersive
44c	0.4	15°R	
44d	0.8	15°R	
44e	1.1	Downstream	
46a	0.0	N/A	Dispersive
46b	0.0	N/A	Dispersive
46c	0.2	45°R	
46D	0.9	15°R	
46c	1.1	Downstream	
			The following are taken at an equivalent depth of 11 ft.
42a	N/A	N/A	
42b	N/A	N/A	
42c	0.9	Downstream	
42d	N/A	N/A	
42e	N/A	N/A	
44a	N/A	N/A	
44b	0.0	5°R	
44c	0.7	Downstream	
44d	0.9	Downstream	
44e	N/A	N/A	
46a	0.0	N/A	
46b	0.0	N/A	
46c	0.4	50°R	
46e	1.3	Downstream	

(*) See definition sketch
(**) Water surface elevation at Pump Intake Station = 213.0 ft.

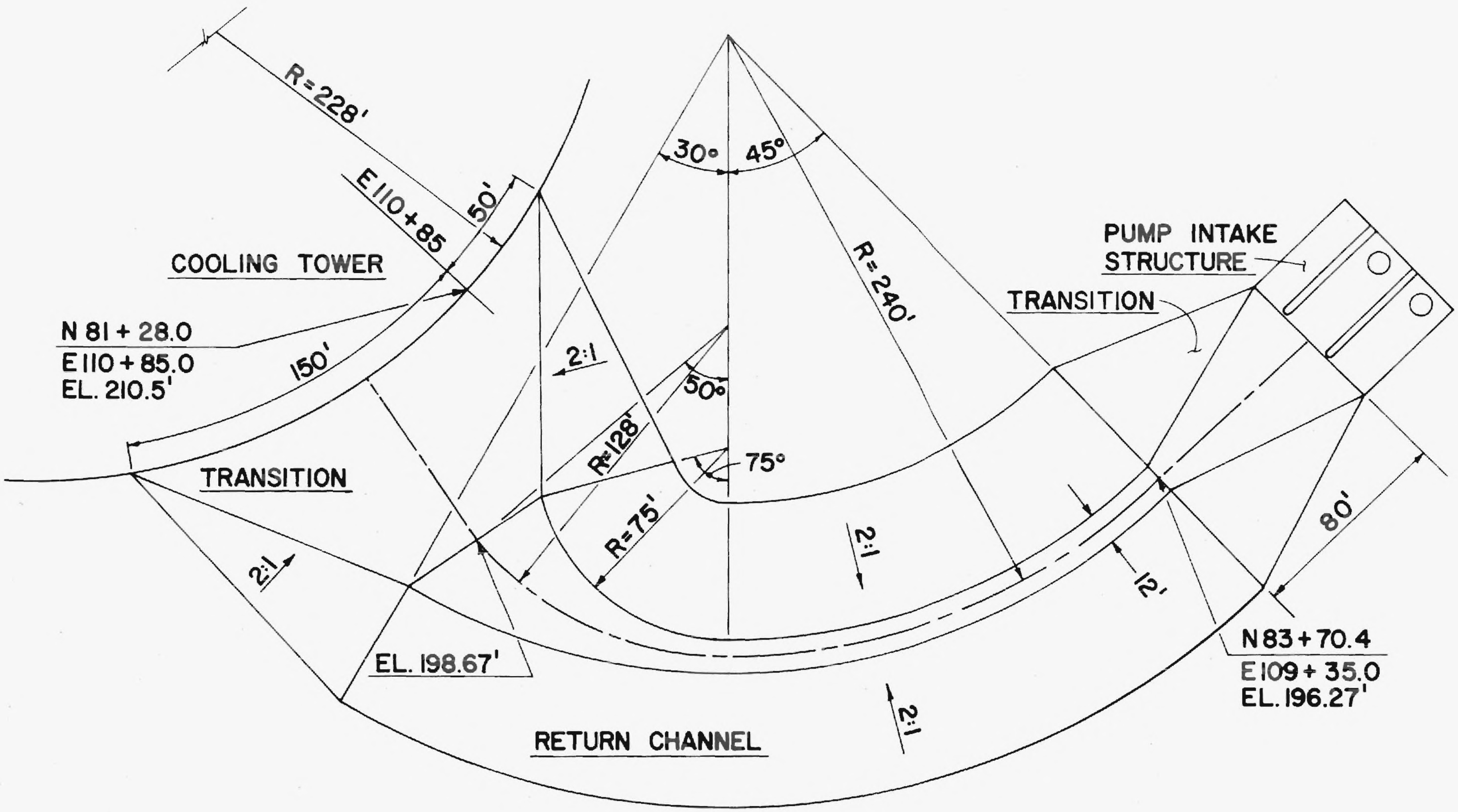

FIGURE 1 : RETURN CHANNEL ALIGNMENT
(CHIOU, 8/12/77)

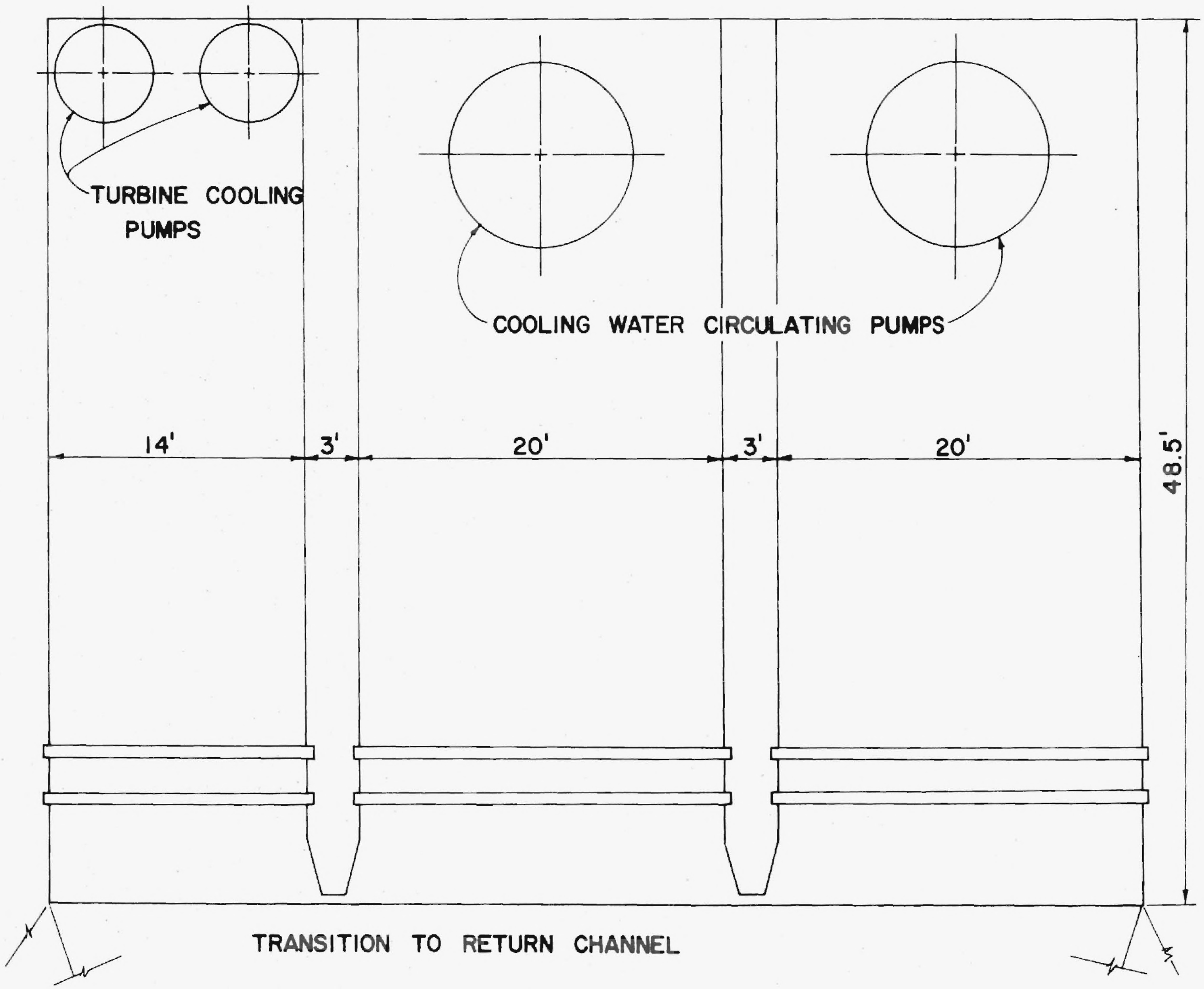

FIGURE 2: PLAN SKETCH
OF PUMP INTAKE
STRUCTURE
(NO SCALE)

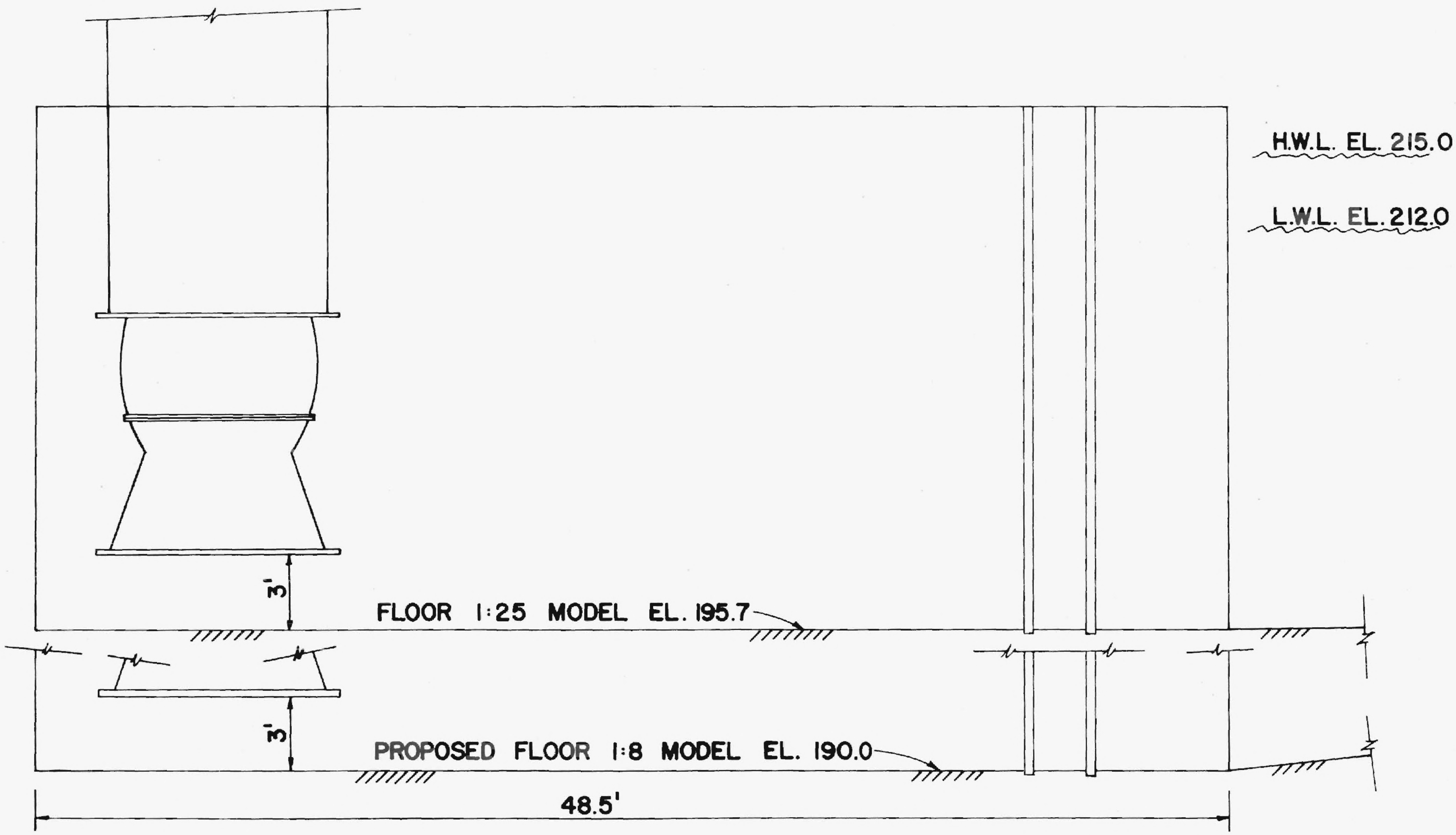

FIGURE 3: ELEVATION SKETCH OF PUMP INTAKE STRUCTURE
(NO SCALE)

FIGURE 4 : OBLIQUE VIEW OF LABORATORY INSTALLATION, 1:25 MODEL

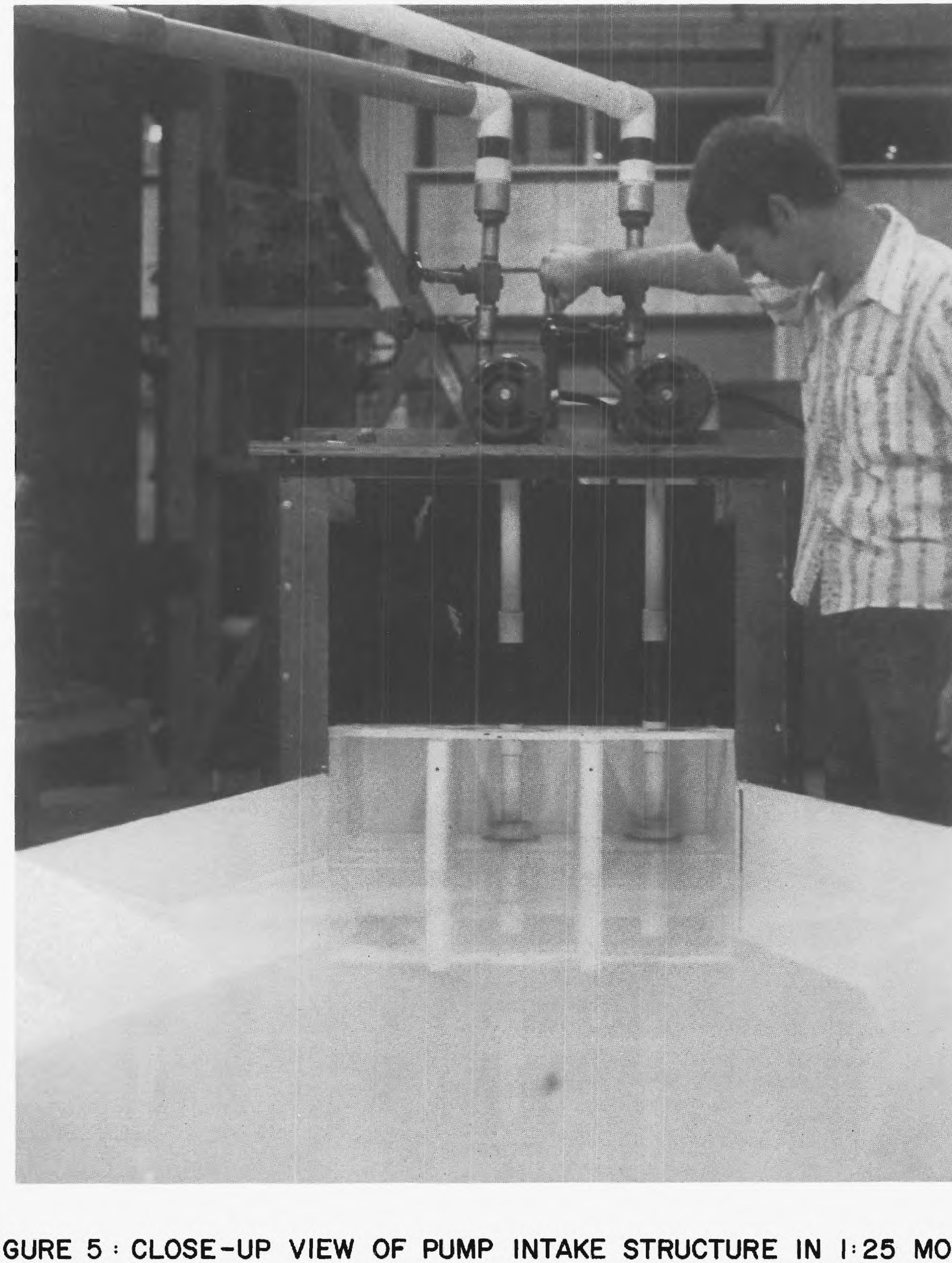

FIGURE 5 : CLOSE-UP VIEW OF PUMP INTAKE STRUCTURE IN 1:25 MODEL

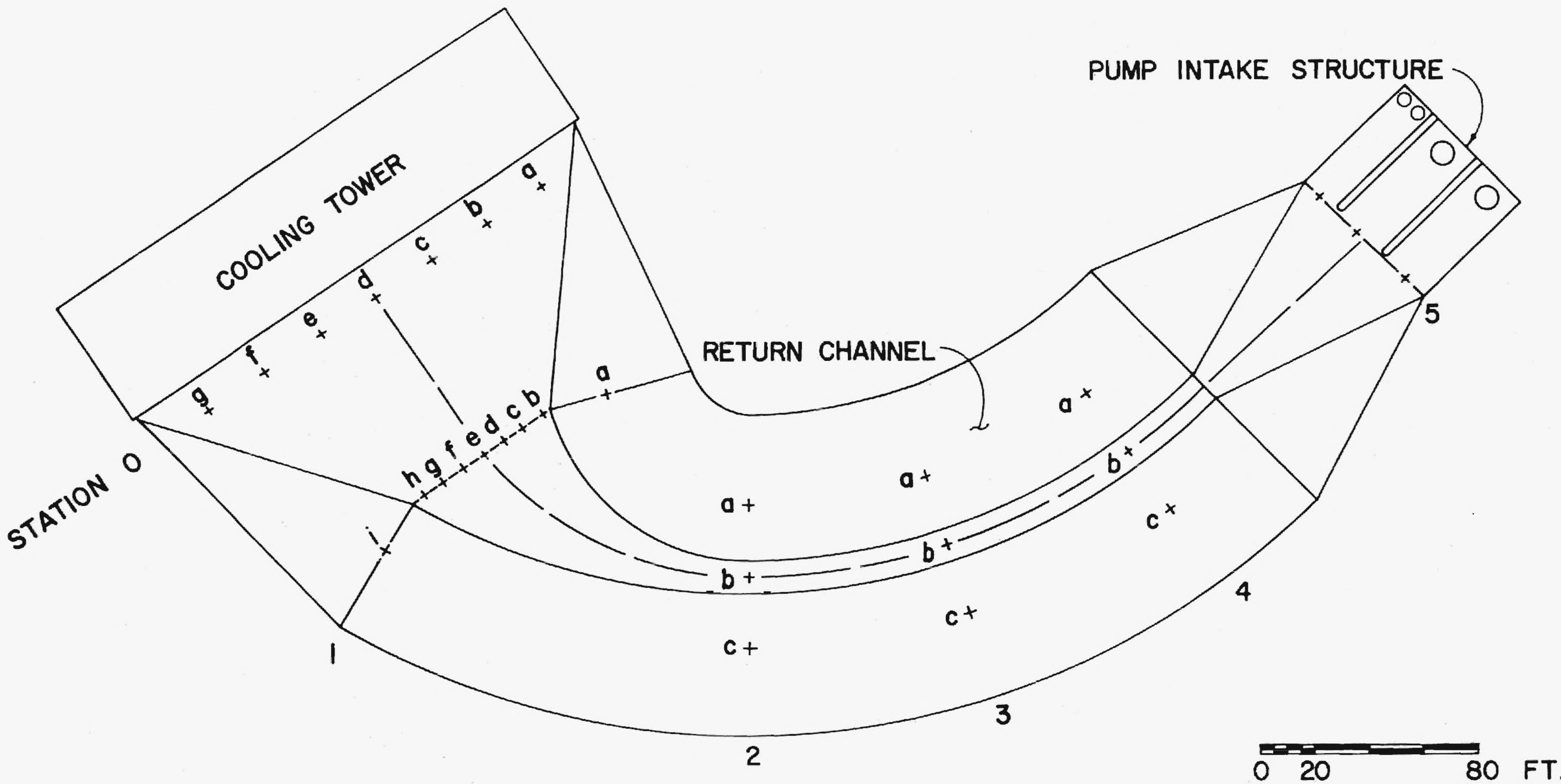

FIGURE 6 : PLAN VIEW OF 1:25 SCALE MODEL SHOWING MEASURING STATIONS

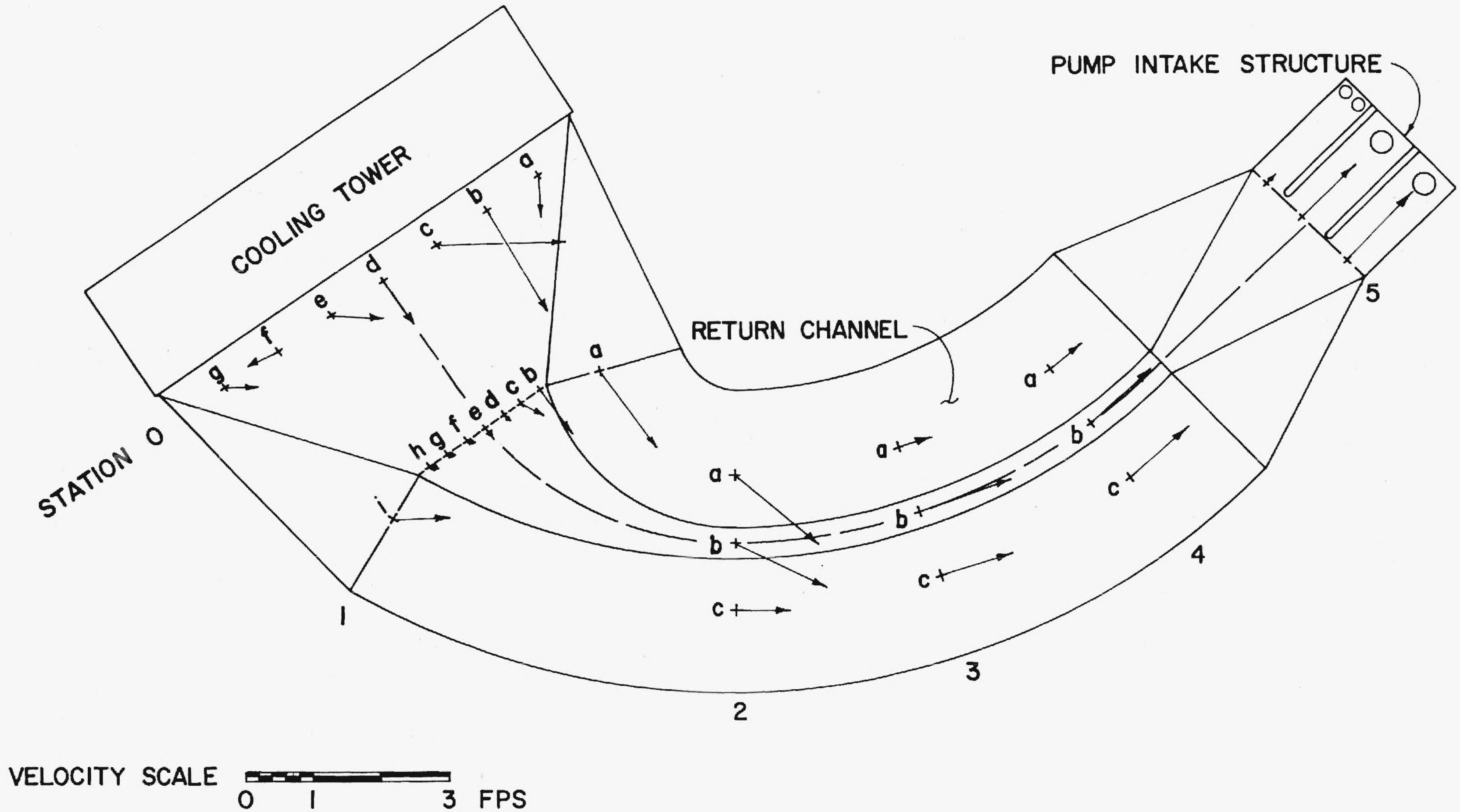

FIGURE 7: VELOCITIES IN RETURN CHANNEL, 1:25 SCALE MODEL
Q = 1110 CFS
W.S. ELEV. AT PUMP INTAKE STRUCTURE: 215.3 FT.

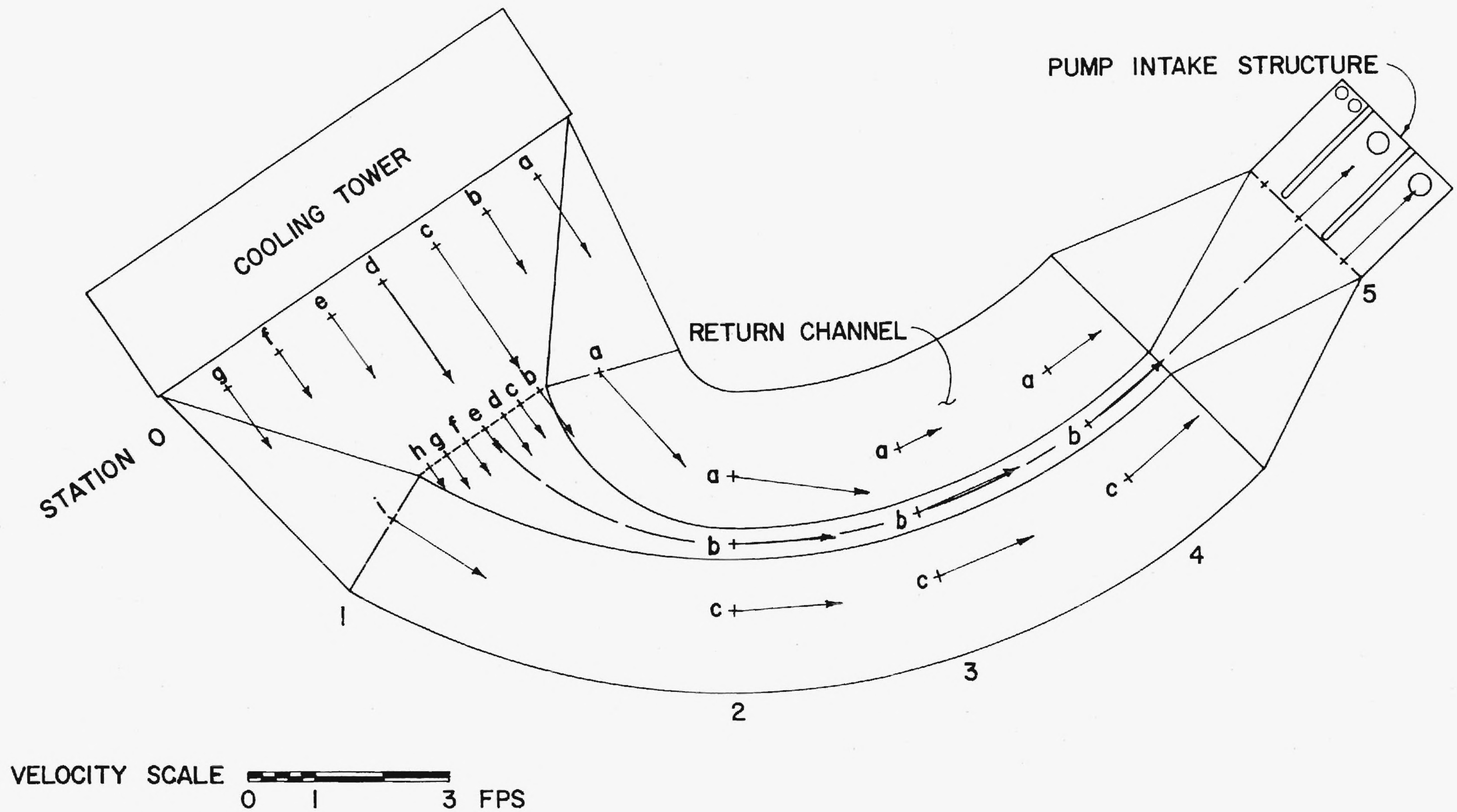

FIGURE 8: VELOCITIES IN RETURN CHANNEL, 1:25 SCALE MODEL
Q = 1110 CFS
W.S. ELEV. AT PUMP INTAKE STRUCTURE : 213.0 FT.

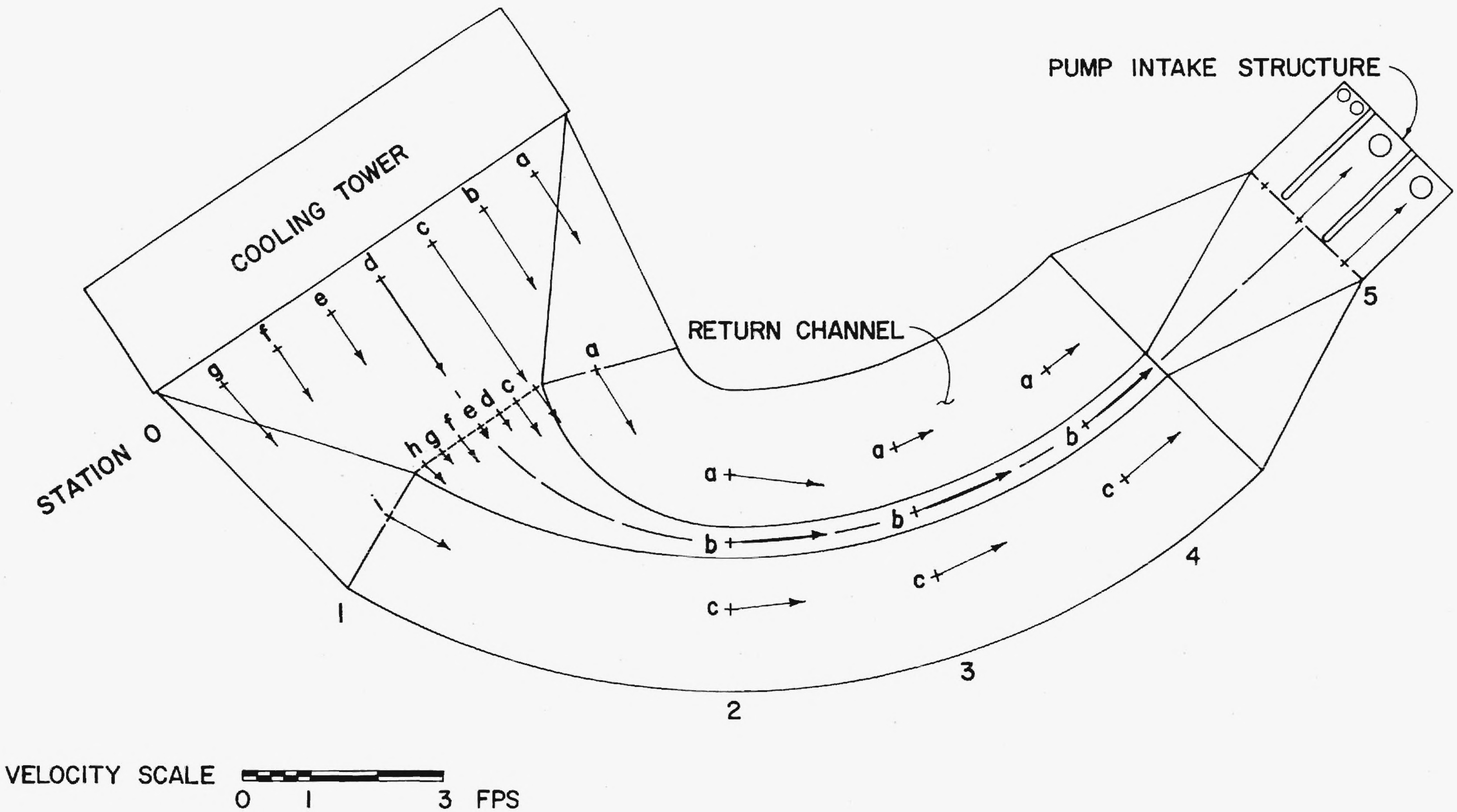

FIGURE 9: VELOCITIES IN RETURN CHANNEL, 1:25 SCALE MODEL
Q = 1110 CFS
W.S. ELEV. AT PUMP INTAKE STRUCTURE : 215.0 FT.

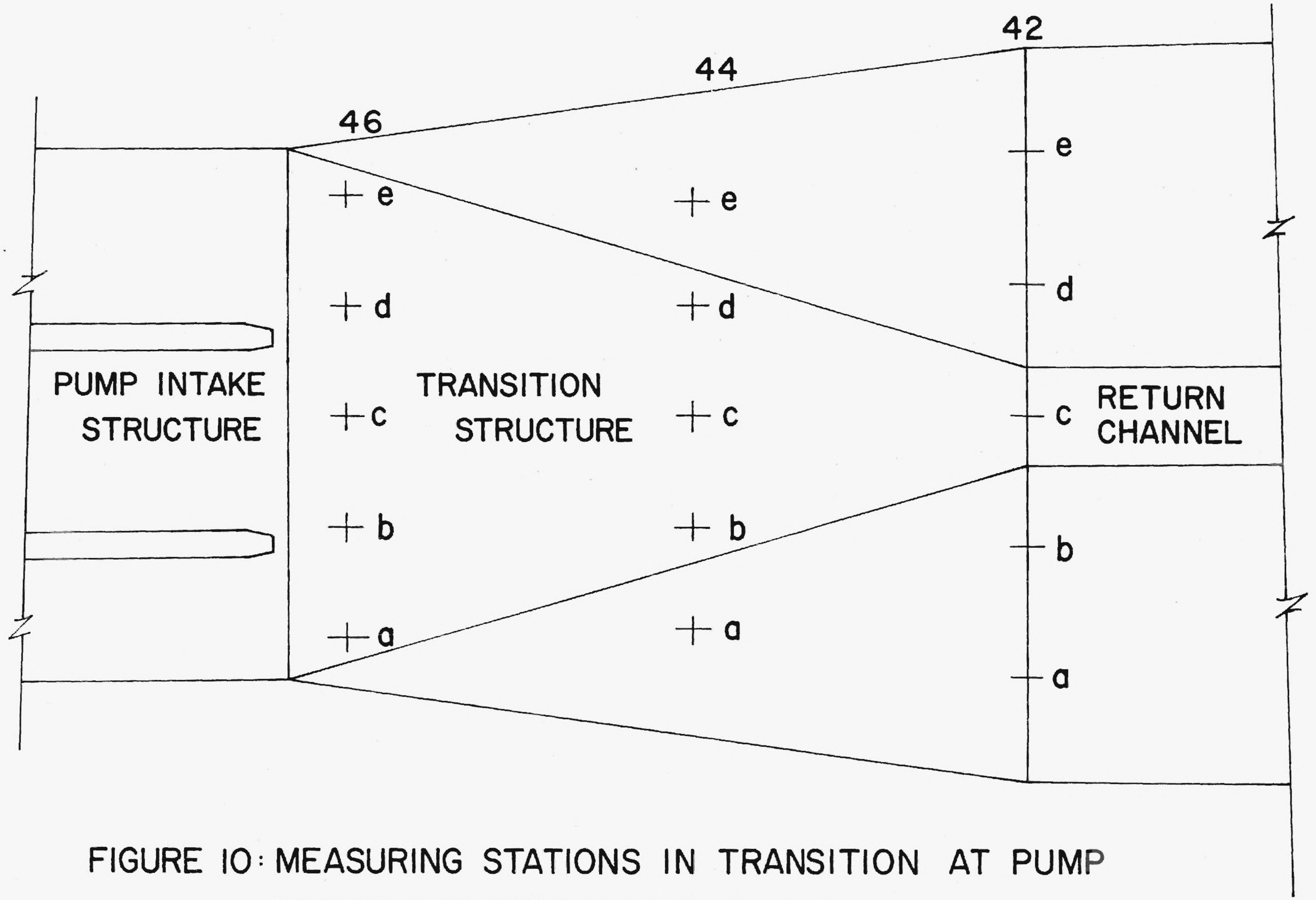

FIGURE 10: MEASURING STATIONS IN TRANSITION AT PUMP INTAKE STRUCTURE (NO SCALE)

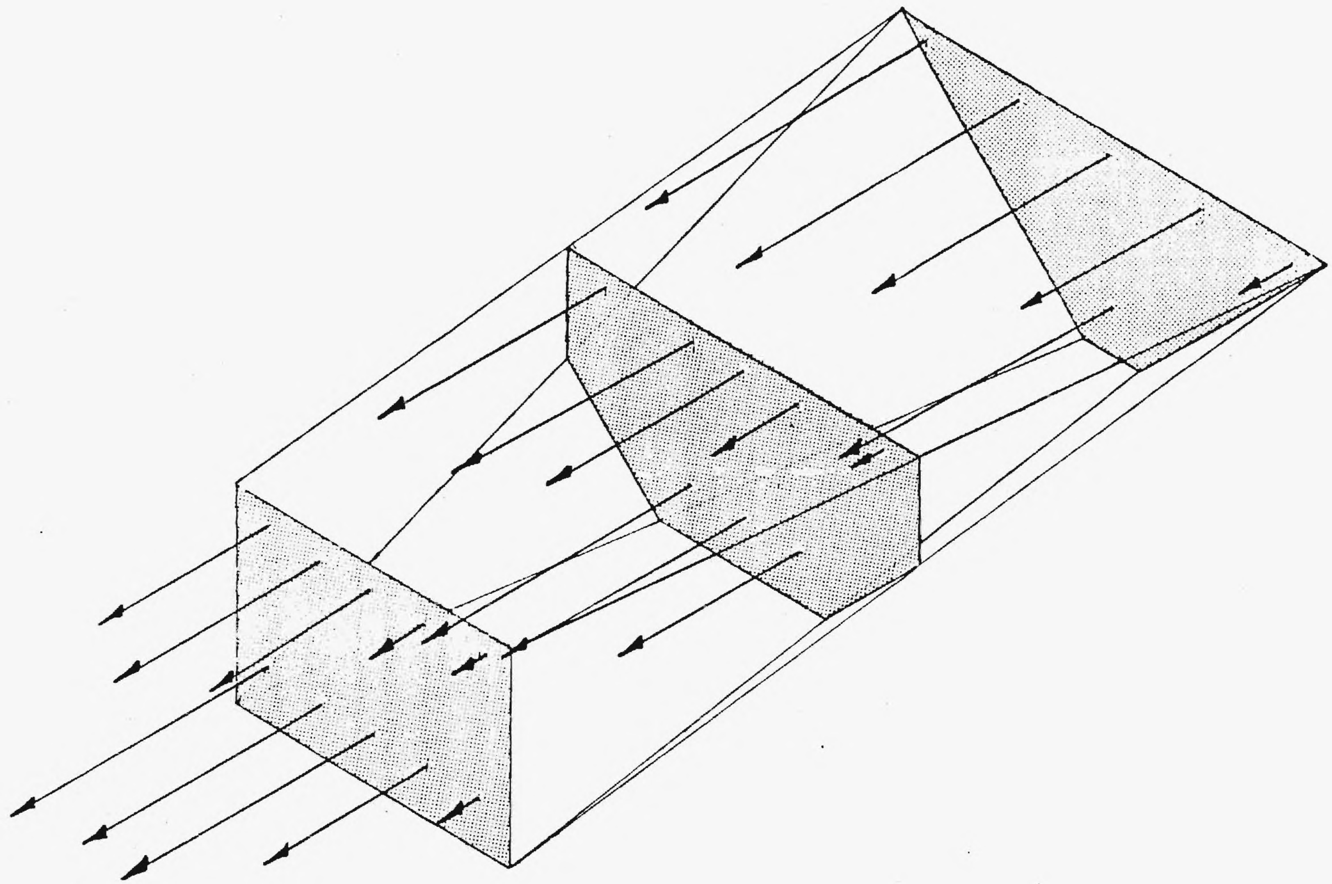

FIGURE 11: VELOCITIES IN TRANSITION AT PUMP INTAKE STRUCTURE
VELOCITY SCALE : 1" = 1 FT/SEC
Q = 1110 CFS W.S. ELEV. = 212.0 FT.

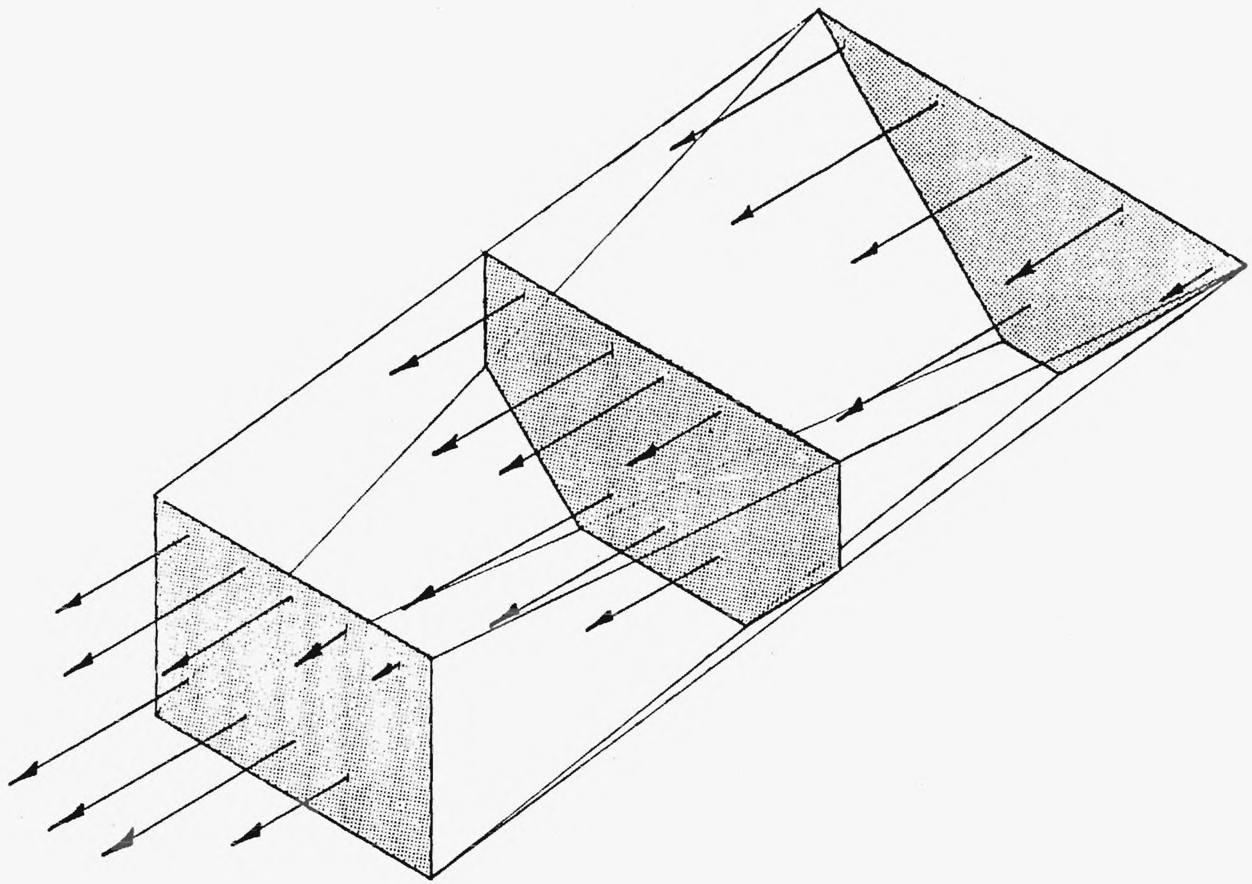

FIGURE 12: VELOCITIES IN TRANSITION AT PUMP INTAKE STRUCTURE
VELOCITY SCALE : 1" = 1 FT/SEC
Q = 1110 CFS W.S. ELEV. = 215.0 FT.

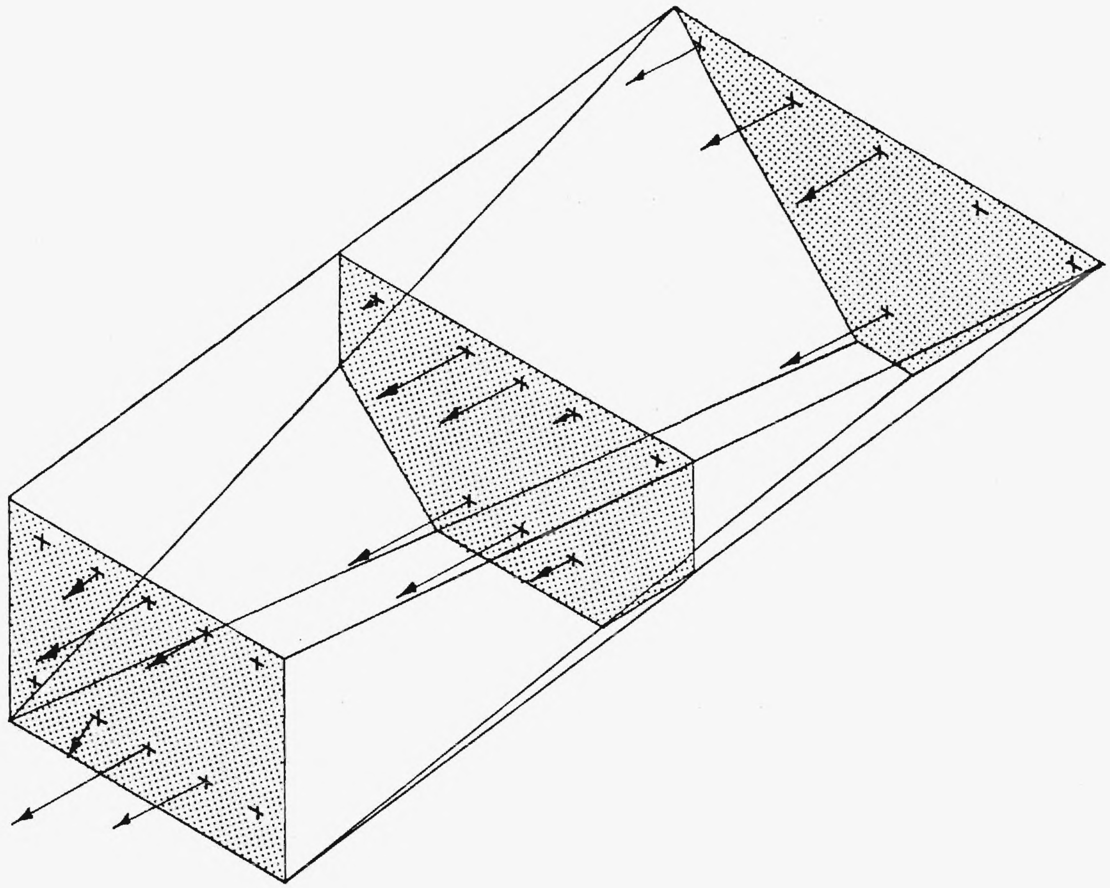

FIGURE 13: VELOCITIES IN TRANSITION AT PUMP INTAKE STRUCTURE
CENTER BAY PUMP ONLY
VELOCITY SCALE : 1" = 1 FT/SEC
Q = 560 CFS   W.S. ELEV. = 213.0 FT.

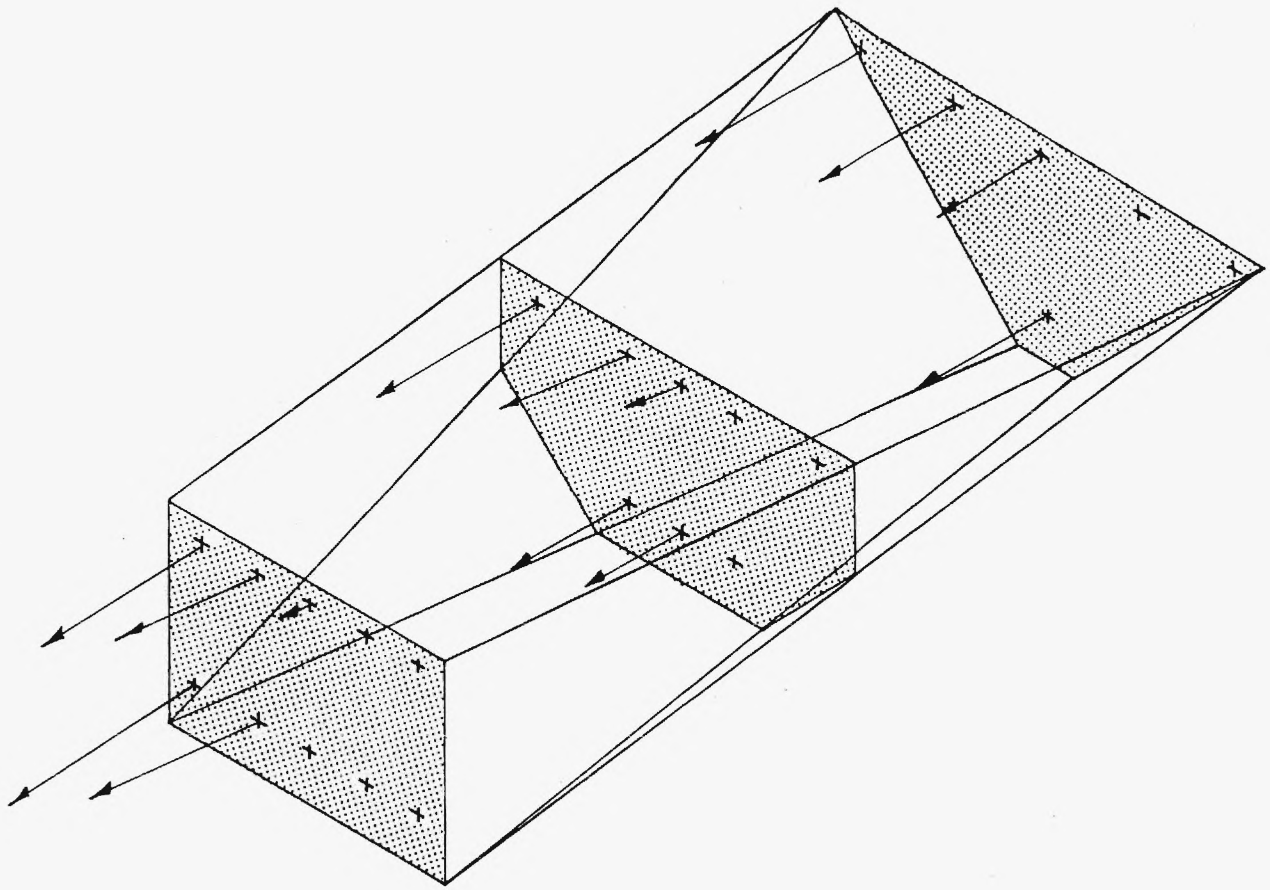

FIGURE 14: VELOCITIES IN TRANSITION AT PUMP INTAKE STRUCTURE
NORTH BAY PUMP ONLY
VELOCITY SCALE : 1" = 1 FT/SEC
Q = 560 CFS W.S. ELEV. = 213.0 FT.

E 20-619

VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

Report No. 2: Construction and Test Results, 1:8 Scale Model

by

Paul G. Mayer

Project No. E-20-619
Southern Company Services
Birmingham, Alabama

Jaunuary, 1978

SCHOOL OF CIVIL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

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VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

Report No. 2: Construction and Test Results 1:8 Scale Model

I. Introduction

The Alvin W. Vogtle Nuclear Power Plant is a proposed electric power generating station of the Georgia Power Company. The location of Plant Vogtle is several miles below the City of Augusta, Georgia, in the proximity of the Savannah River. The design of Plant Vogtle has been carried out by the Bechtel Corporation of Los Angeles, California, under contract to the Southern Company Services, Incorporated, of Birmingham, Alabama, and the Georgia Power Company with headquarters in Atlanta, Georgia.

The circulating cooling water system of Plant Vogtle is an essential component of that facility. Its design, design verification, and design modification are the subject of careful study and review. In this context, Southern Company Services contracted with the Georgia Institute of Technology, School of Civil Engineering, to build and test a hydraulic model of the circulating water system intake structure. The liaison with Southern Company Services was carried out through Mr. G. B. Dougherty. The principal investigator was Dr. Paul G. Mayer, Regents' Professor of Civil Engineering, Georgia Institute of Technology.

Preliminary tests were conducted on a 1:25 scale model of the circulating water channel and pump intake structure. These efforts were reported in the "Report No. 1, Construction and Test Results", dated and transmitted on September 16, 1977.

This report summarizes all subsequent studies which were conducted with a 1:8 scale hydraulic model. This Report No. 2 is also the final report on the Plant Vogtle model tests conducted under the terms of the present contract and as enumerated in Chapter II, Purpose and Scope.

II. Purpose and Scope

In general, the performance of centrifugal pumps may be significantly influenced by flow conditions in the pump intake structure. Adverse flow conditions may lend to loss of pump efficiency, air-entrainment, and vibrations.

The presence of swirling motions and of asymmetrical inflows into a pump bay may lead to vortex formation and prerotation of the flow into the pump impeller. In cases of strong and persistent circulation the flow patterns may lead to air-entrainment. Both prerotation and air-entrainment adversely affect pump efficiencies. In cases of a multi-pump system as in the Plant Vogtle Cooling Water System, the flow patterns may vary from bay to bay and may result in uneven performances by the various units of the system.

In performing the model investigation, the tests were directed toward identifying possibly adverse flow patterns and to propose such changes to the presently proposed pump intake structure which would enhance the performance of the system.

The hydraulic model tests were to be carried out on a 1:8 scale model of the cooling water intake structure to ascertain prevailing flow conditions and flow patterns and to establish specifically:

a. the flow patterns and velocity distribution in the approach channel,

b. the flow patterns and velocity distributions in the pump bays,

c. the flow patterns and velocity distribution in close proximity of the circulating water pump suction bells, and

d. the amount and direction of prerotation of the flow in the pump suction pipes.

All test results together with observation and recommendations were to be submitted in a final report. Any extension of the scope of the hydraulic model tests, any modification of the pump intake structure, or any other work was not to be undertaken except by mutual agreement between the principal parties and by extension of the present contract.

III. The Hydraulic Model

In modeling the Plant Vogtle Pump Intake Structure, both geometrical and dynamical similitude requirements were considered. It was agreed that the dynamical similitude must be based on the Froude criterion and that the viscous effects and and the surface tension effects can be neglected. The effects of the viscous forces on the general flow patterns in the model were minimal in view of the large Reynolds number flows which insured the presence of fully turbulent conditions. The influence of viscosity and of surface tension on the formation of air-entraining vortices is not yet understood. However, since the air-entrainment is connected with free surface vortices, the absence of such vortices in the model is usually accepted as a satisfactory test result.

A 1:8 scale undistorted model was built. The corresponding velocity scale was 1:2.83, and the model discharges were based on a ratio of 1:181.

The model was built to conform to design drawings provided by the Southern Company Services. A schematic plan view of the system is shown in Figure 1. In the proposed prototype, the cooling water is collected in a large circular basin underneath the cooling tower. The water is then discharged into a trapezoidal channel and returned into the pump intake structure. The trapezoidal channel has a 12-foot wide bottom and side slopes of one on two. A channel transition then conveys the flow into the rectangular pump intake structure.

The extent of the 1:8 scale model is shown in Figure 2. The cooling tower and a portion of the return channel were simulated by a head tank, some twelve feet wide, eight feet long, and four feet deep. Some 16 feet of trapezoidal channel in the model represented about 130 feet of the prototype channel, or some 65 percent. The channel transition was modeled in its entirety, as was the pump intake structure. A plan view of the intake structure model is shown in Figure 3, and a longitudinal profile of the model is shown in Figure 4. Figure 5 shows an elevation view of the intake structure.

In the prototype intake structure, there are two bays to house one circulating water pump each with a rated capacity of 242,000 gallons per minute, or about 542 cubic feet per second. A third bay accommodates two turbine cooling water pumps with a rated capacity of 14,000 gallons per minute each.

In the model, the pumps were simulated by horizontal centrifugal pumps with appropriately shaped suction bells. Figure 6 shows the location of the pumps above the intake structure model during construction. An overall view of the model during construction is shown in Figure 7. The pump suction lines and the return lines were made of fiberglass and shaped to yield optimal hydrodynamic flow conditions. At each end of the return lines, sections of six-inch diameter spiral-weld pipe contained calibrated elbow meters and flow control valves.

During operation of the model, local velocities were measured with a calibrated midget current meter. The flow directions were traced by means of dye-streaks. Flow patterns around the pump bells were observed by means of dye-streaks and by means of colored tufts mounted on wire poles. Close visual inspection was accommodated by plexiglass windows in the pump bays. Figure 8 shows an upstream view of the model during operation. Figure 9 shows the model intake structure during operation. A metal shroud was place over the PVC suction pipe to correspond more closely to the prototype dimensions of the circulating water pumps. A close-up view of the pump suction bell and the colored tufts as seen through a plexiglass window is shown in Figure 10.

For the study of prerotation of flow in the suction pipes, vortimeters were fabricated and installed. These vortimeters consisted of four-bladed no-pitch propellers mounted inside the riser pipes of the suction lines. For observation of the prevailing prerotating flow patterns, plexiglass windows were inserted into the PVC suction pipes. Figure 11 shows an installed vortimeter.

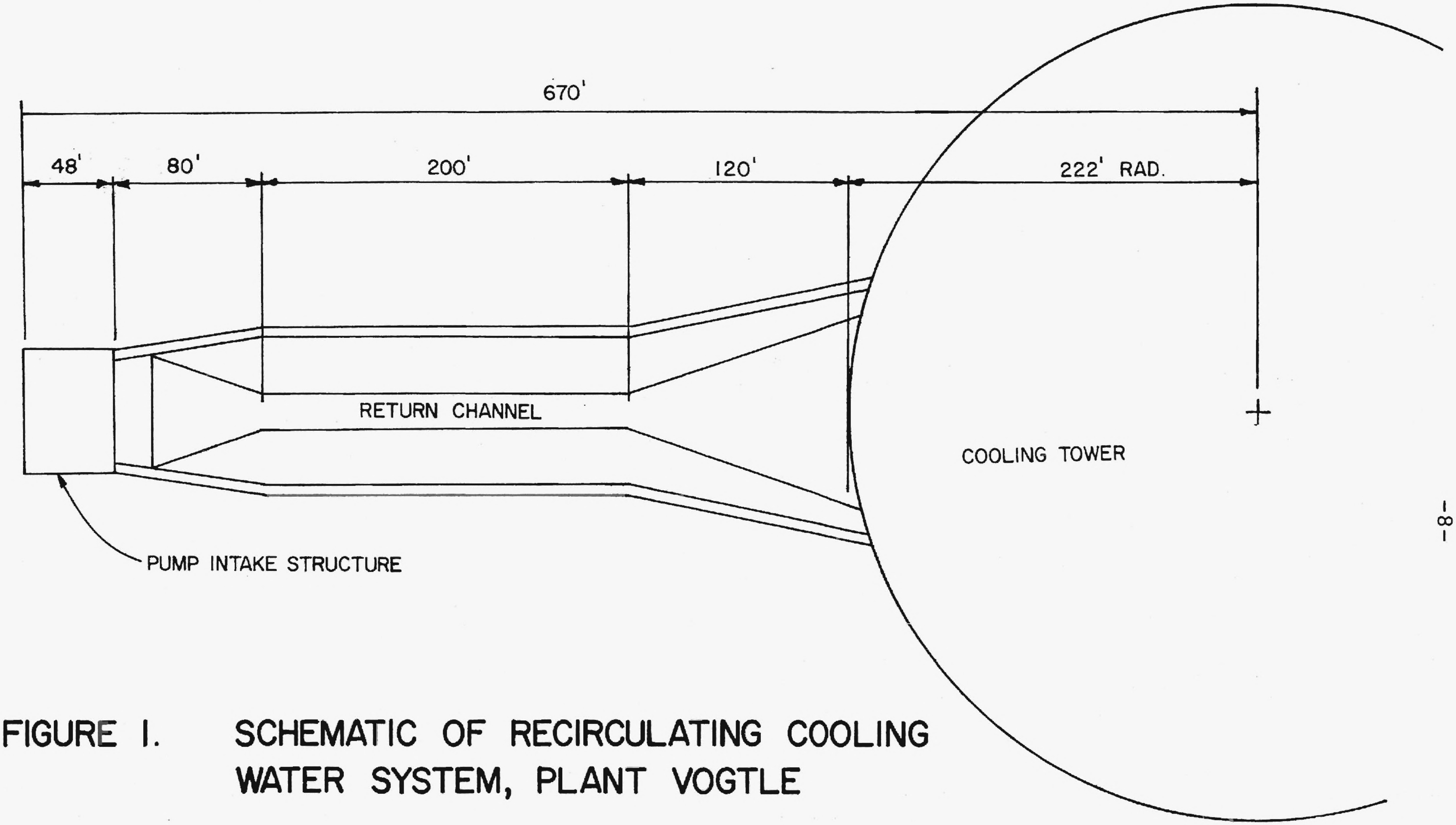


FIGURE 1. SCHEMATIC OF RECIRCULATING COOLING WATER SYSTEM, PLANT VOGTLE

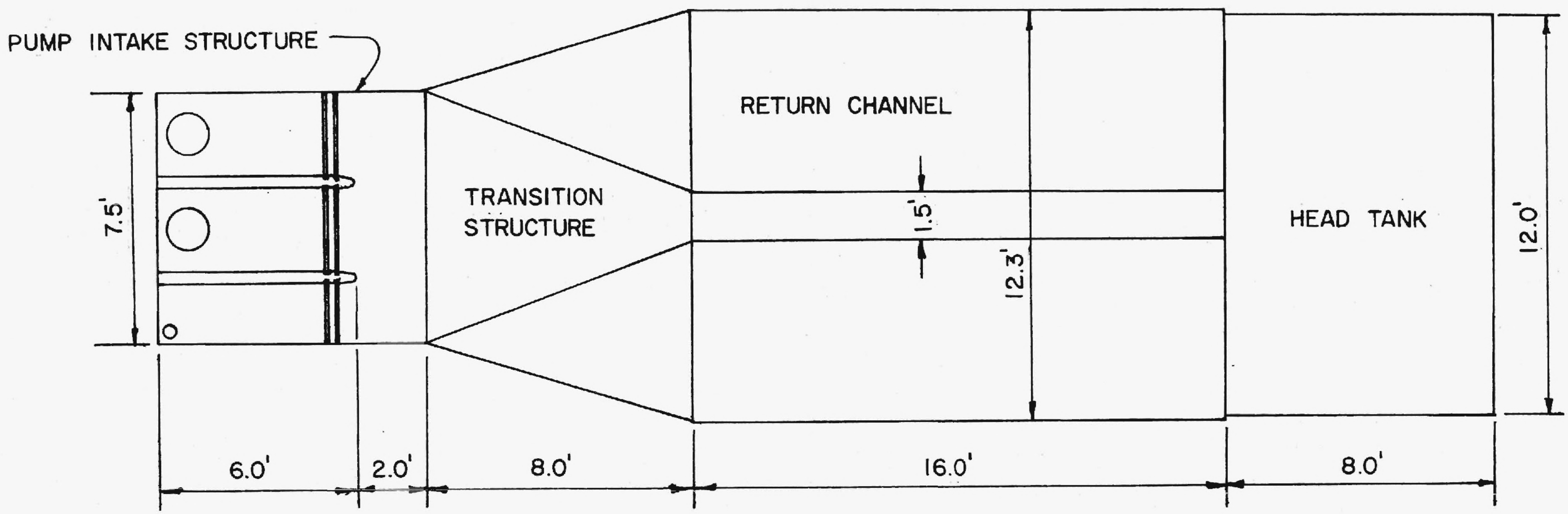


FIGURE 2. SCHEMATIC OF 1:8 HYDRAULIC MODEL

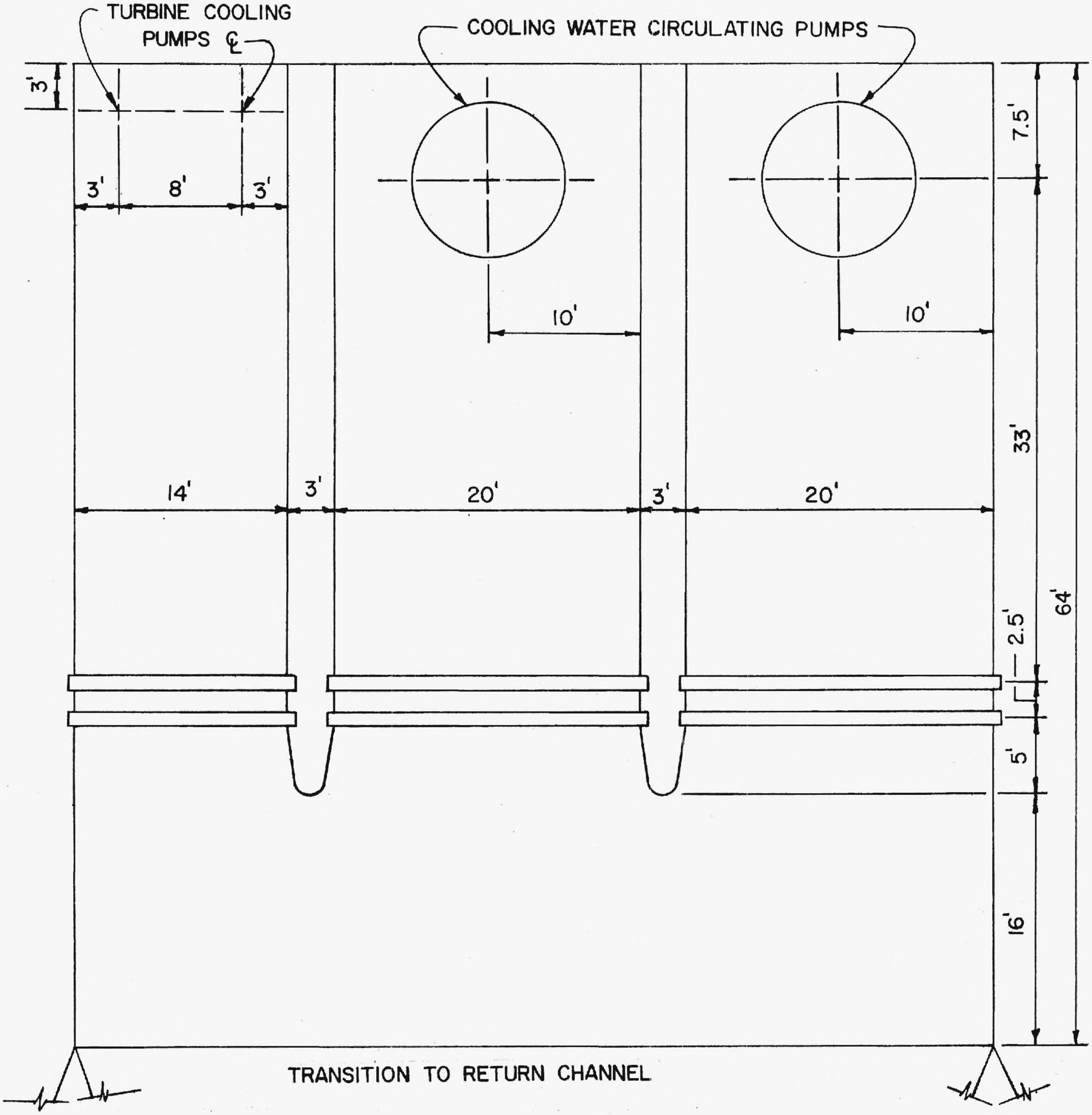


FIGURE 3. PLAN VIEW OF PUMP INTAKE STRUCTURE, PLANT VOGTLE

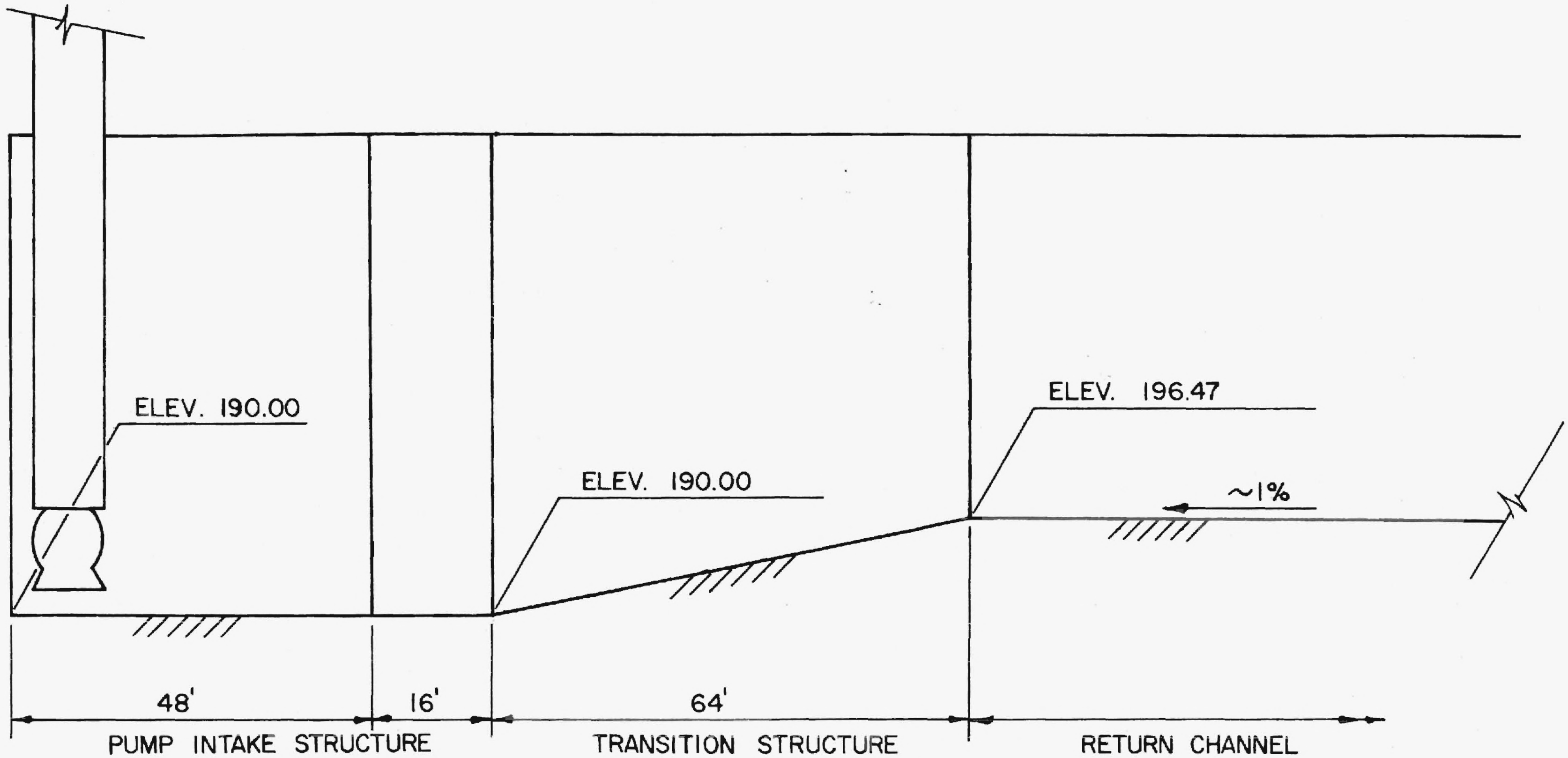


FIGURE 4. ELEVATION VIEW OF HYDRAULIC MODEL (PROTOTYPE DIMENSIONS)

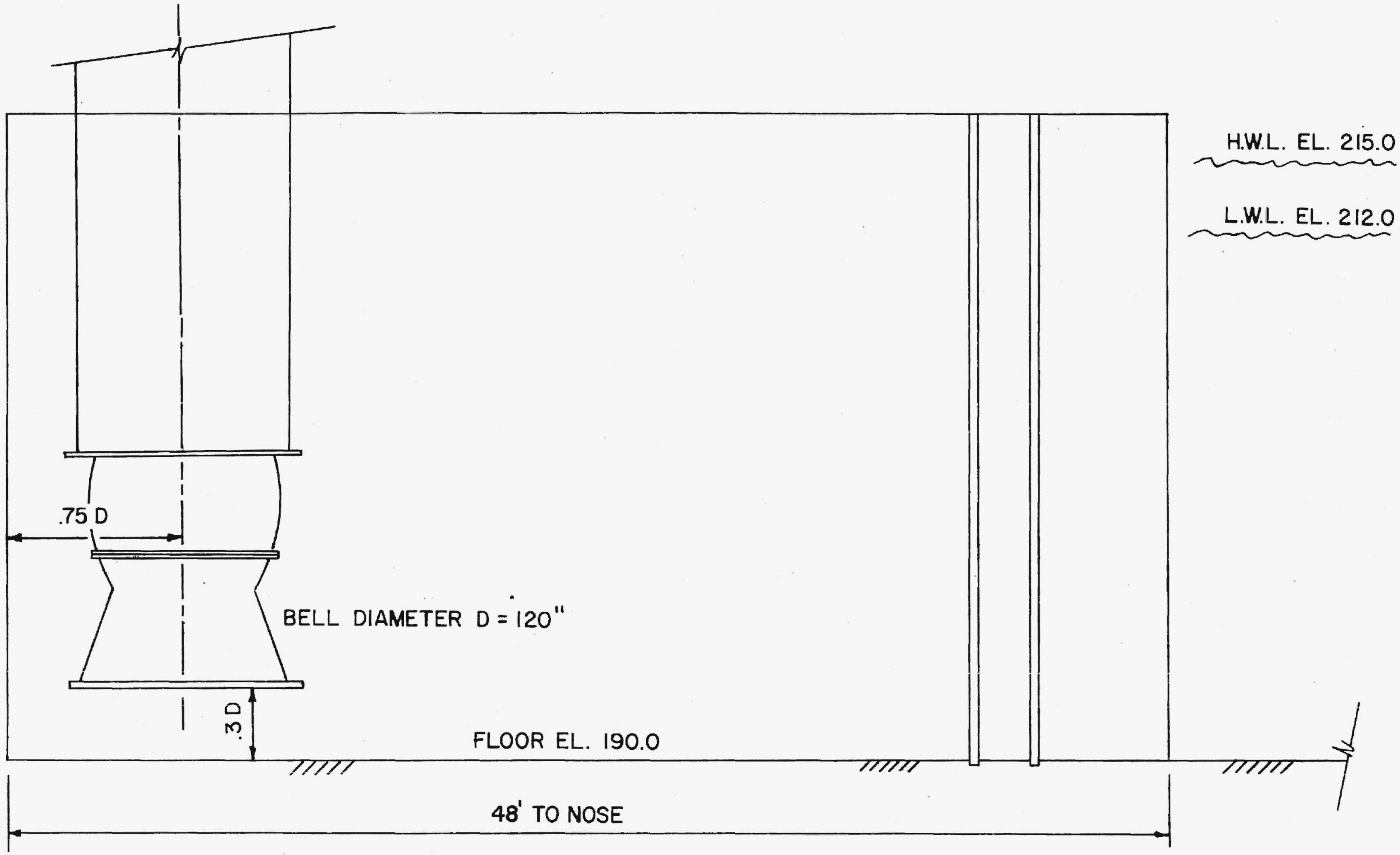


FIGURE 5. ELEVATION VIEW OF PUMP INTAKE STRUCTURE, PLANT VOGTLE

Figure 6. View of Pump Intake Structure During Construction, 1:8 Model.

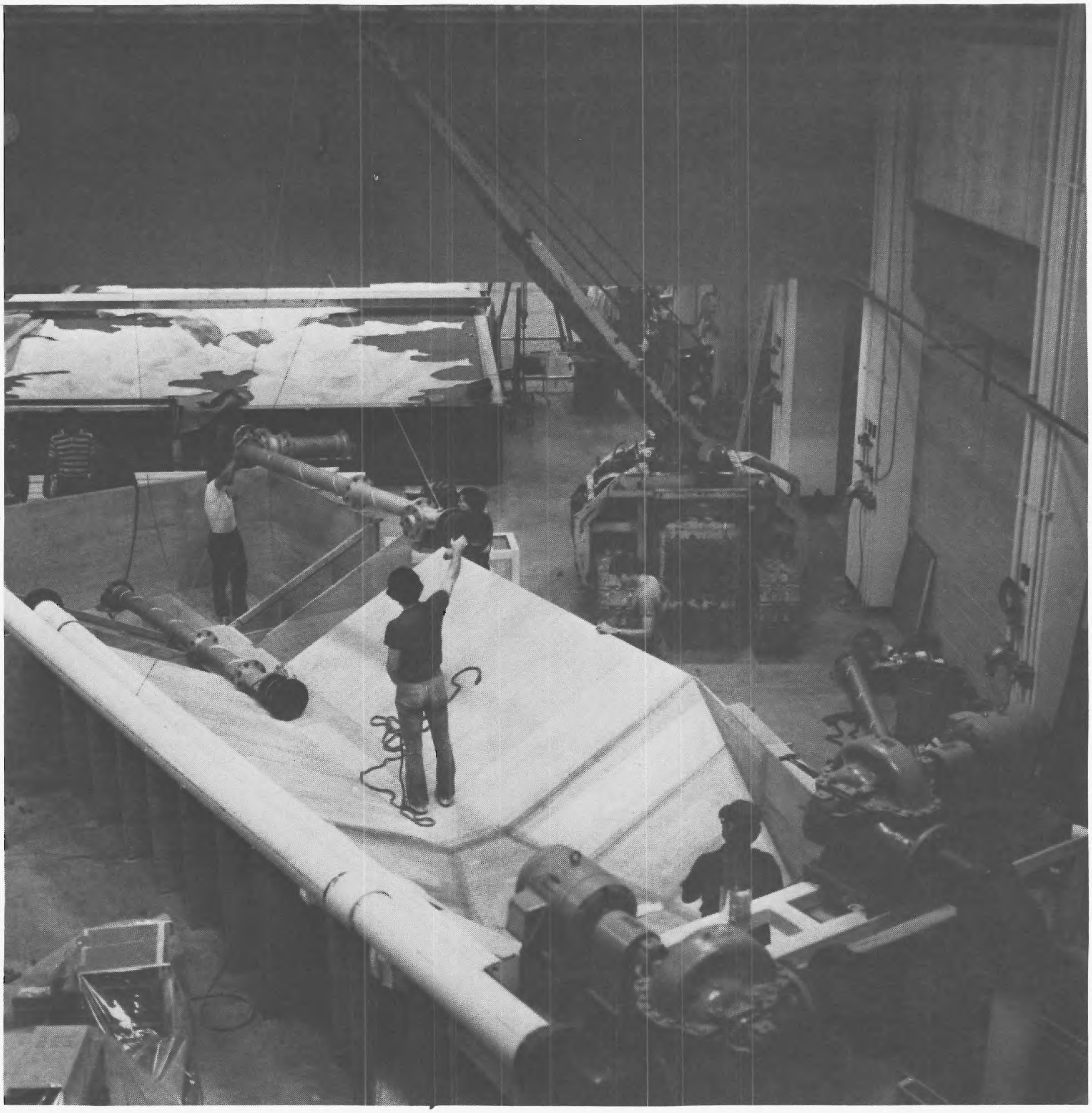


Figure 7. Overall View of Model During Construction.

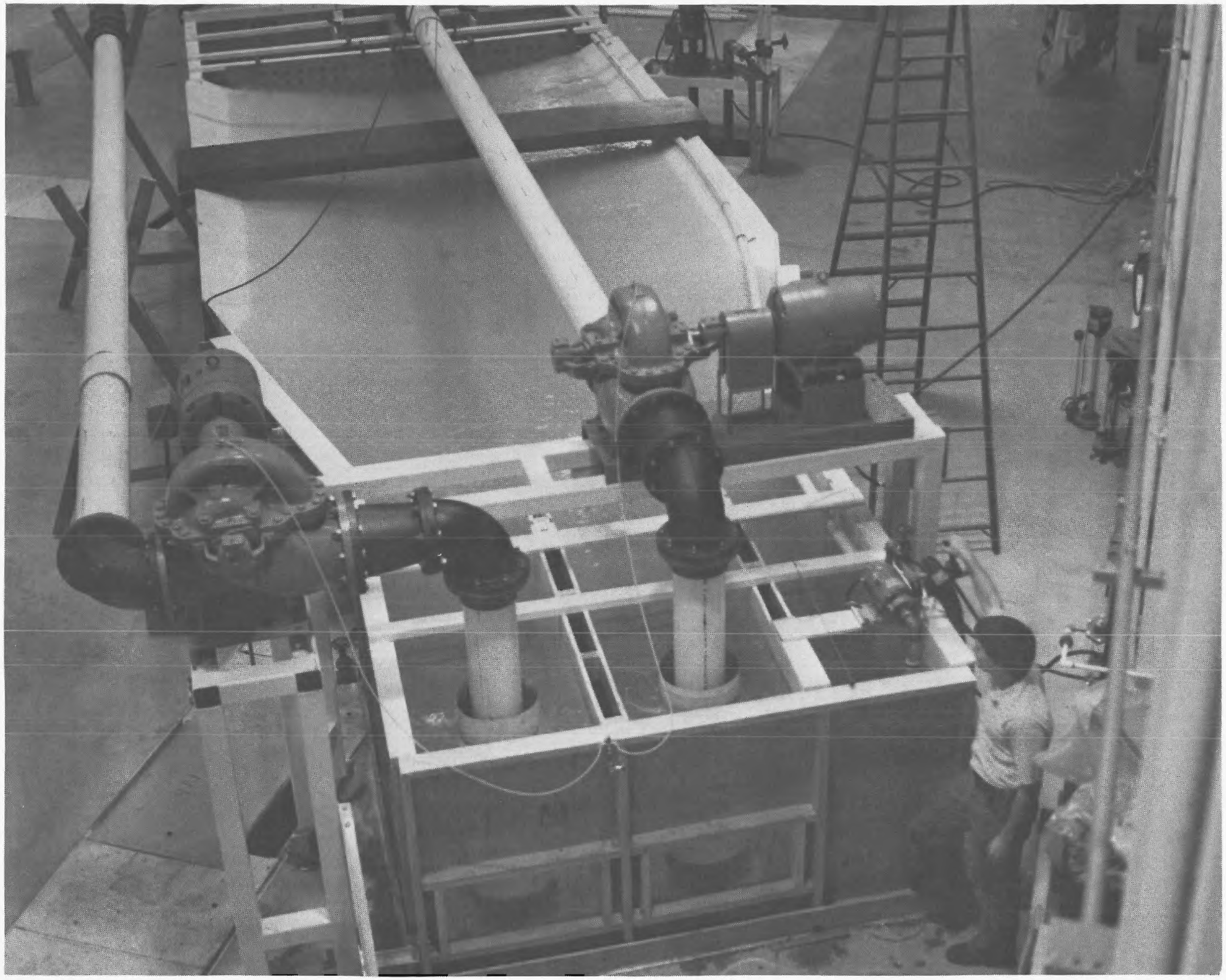


Figure 8. View of Model During Operation.

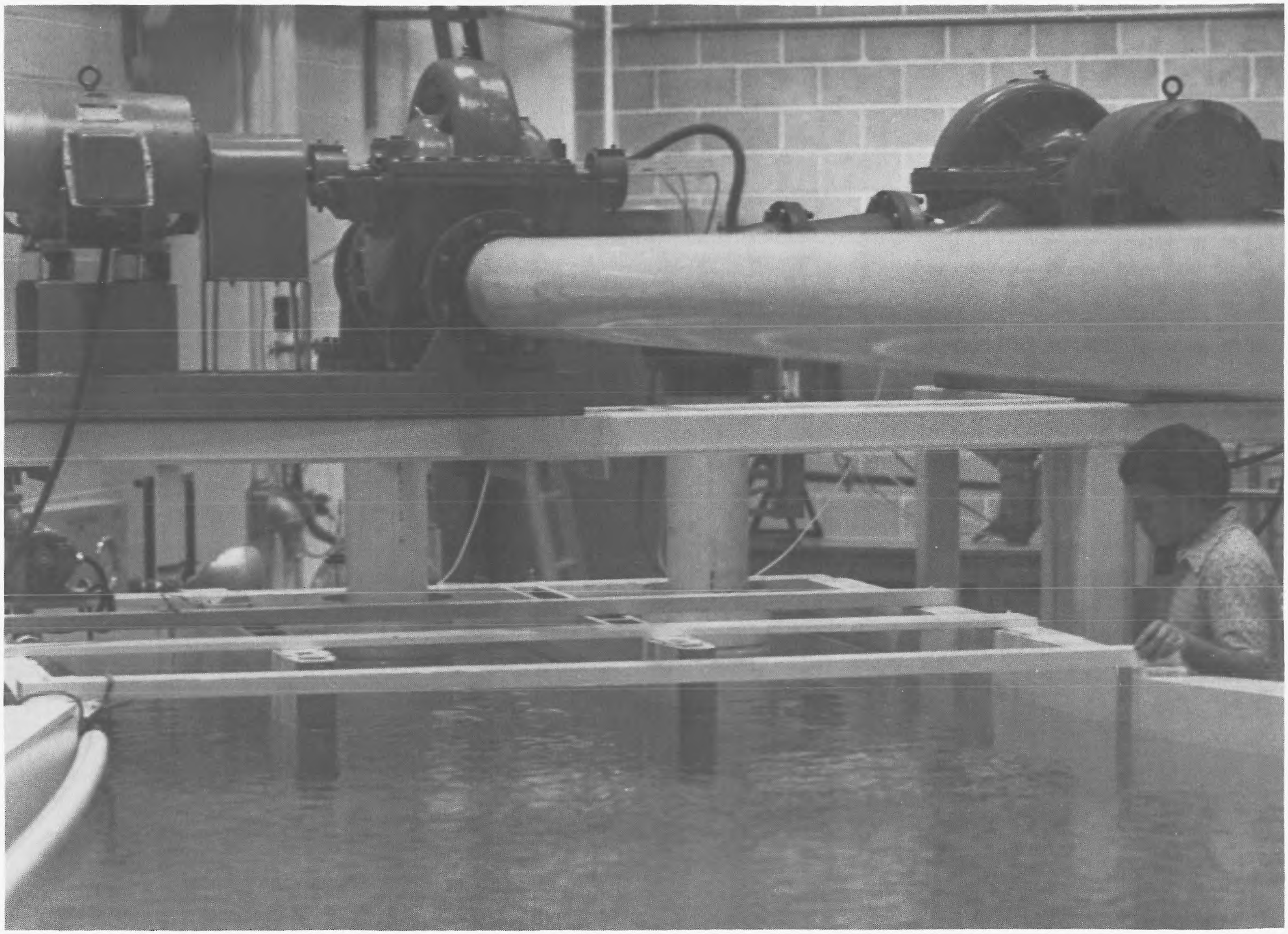


Figure 9. Intake Structure During Operation.

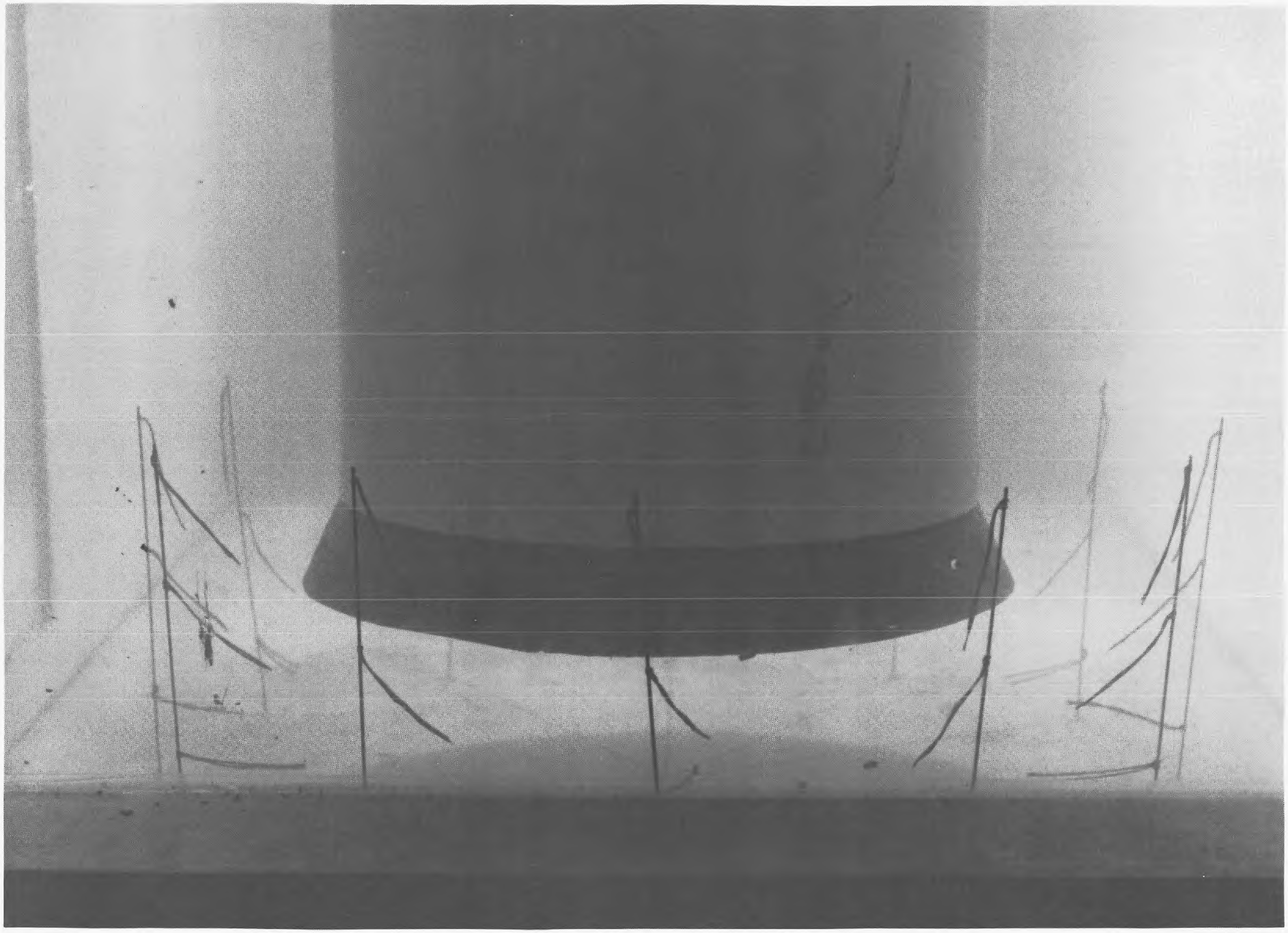


Figure 10. Close-Up of Pump Suction Bells During Operation.

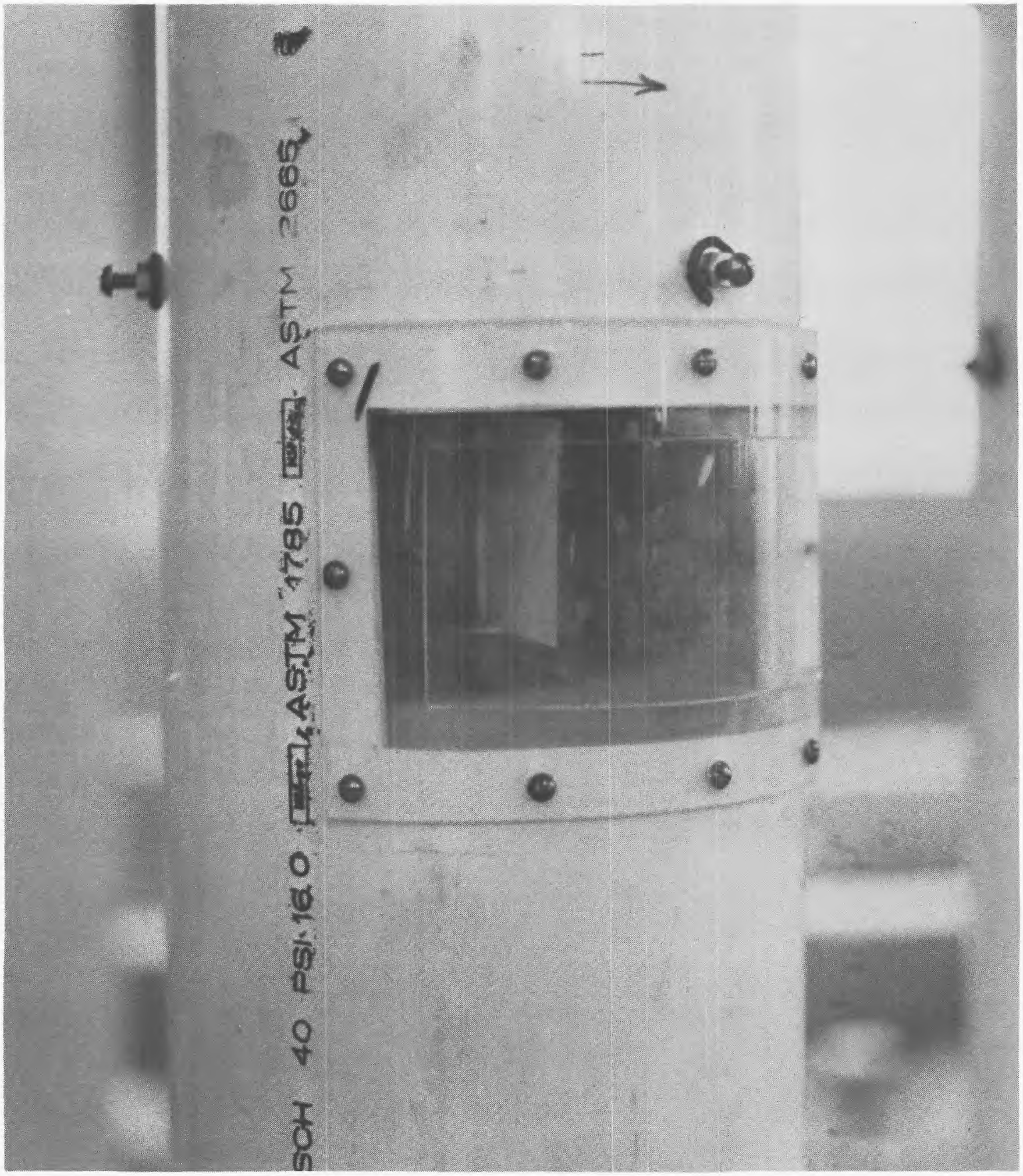


Figure 11. Close-Up of Vortimeter in Suction Line.

IV. Test Procedures

After the 1:8 scale model was built, a meeting was held in the Georgia Tech Hydraulics Laboratory on November 4, 1977, to establish test procedures and test criteria. The meeting was attended by representatives of Bechte., Georgia Tech, Ingersoll-Rand and Southern Services (see Memorandum from C. B. Heard, Southern Company Services, to J. M. Hire, Southern Company Services dated November 10, 1977; and letter from J. D. Duffin, Project Engineer, Bechtel Power Corporation, to W. M. MOore, Project Administration Manager, Georgia Power Company, dated December 2, 1977).

Preliminary observations of the model flows had indicated a strong dependency of the intake structure flow patterns on flow conditions prevailing in the head box. The dissipation of large-scale turbulence created in the head box by the concentrated return flow jets was essential. Rolls of wire-mesh fencing together with perforated baffle plates were inserted into the head box to provide adequate stilling. Subsequent measurements of velocity distributions in the return channel showed near-uniform flow. Importantly, the stilling of the flow in the head box also eliminated essentially all surface vortices previously observed during preliminary tests.

During the November 4, 1977, meeting it was indicated by C. B. Heard of Southern Services that the floor elevation of the intake structure had been lowered by two feet to an elevation of 188 feet MSL. By then, the model had been built with its floor at the previous design elevation of 190 feet. It was agreed during the November 4 meeting (see above) that the model test could proceed in the as-built configuration with the minimum water surface in the model raised accordingly to give the increased pump bell submergence as required by the pump manufacturers.

Systematic test series were then conducted to establish:

a. velocity distributions in the return channel,

b. flow pattern in the proximity of the circulating water pump bells, and

c. prerotation in the suction lines.

Return Channel Velocity Distributions

Velocity measurements were made in the trapezoidal return channel at six stations and in the intake structure at 29 stations. Figure 12 shows the location of the measuring stations in the 1:8 scale hydraulic model. As indicated in Figure 12, the first measuring station (Station 10) was located some five pumpbell diameters, or 50 feet, upstream from the end of the trapezoidal return channel. Another station in the trapezoidal channel was Station 20 located at its end or at the beginning of the channel transition. Subsequent measuring stations were located in the intake structure and were designated as Stations 30, 40, 50, 58 and 60. AT Station 10 and 20, measurements were made at two feet (elevation 212 feet, prototype dimensions) below the water surface (elevation 206 feet) at the center line location only. Within the intake structure, velocity measurements were made at two feet, eight feet and sixteen feet below the water surface at all locations (elevations 212, 210, 198 feet). The water surface elevation was maintained at 214 feet (minimum water surface elevation of 212 feet plus two feet of additional submergence to simulate the lowered intake structure floor).

The circulating water pumps were designated as Center pump and North pump to reflect their locations within the intake structure, with the North pump being located in the outside pump bay. One turbine cooling water pump was operated during all test sequences. Velocity measurements were made for six different pump operating modes. The pump operating modes are shown in Table 1.

Table 1. Pump Operating Modes

Mode	North	Center	Comments
1.	542	542	Design flow, Q = 542 cfs.
2.	542	0	Maximum flow, North Pump, Q = 650 cfs (120% Design Flow).
3.	0	542	
4.	650	677	Maximum flow, Center Pump, Q = 730 cfs (135% Design Flow).
5.	650	0	
6.	0	730	

Pump Bell Flow Patterns

For the purpose of documentation of the flow pattern near the pump suction bells, tufted brass poles were located in twelve positions at a radial distance of .75D, or 90 inches (prototype), from the pump suction bell center line. The tufts were mounted at 16 inches, 40 inches and 60 inches above the floor of the intake structure. The results gave the direction of the local velocities in their horizontal projections. Again, these observations were recorded for the six pump operation modes listed previously in Table 1.

Prerotation in Suction Lines

In each circulating pump suction line a no-pitch propeller (vortimeter) was installed. Transparent sections of plexiglass were inserted into the suction lines to allow for observation of prerotation. For each of the six pumping modes, several sets of observations were recorded to obtain valid results. In order to eliminate biased results from possibly different behavior of the two vortimeters, the suction lines were exchanged and another test sequence was undertaken.

V. Test Results

All test results represent repeated test sequences. The results are listed in tabular form and are presented as graphs where appropriate. Generally, all test sequences were carried out for the six pumping modes listed in Table 1, and results are reported for velocity distributions in the return channel, pump bell flow patterns, and prerotation studies.

Return Channel Velocity Distributions

Table 2 lists the velocities for the depth of two feet with both circulating water pumps operating at Q = 542 cubic feet per second (design flow). The velocities are shown in prototype magnitudes. The directions were determined by dye-streaks. Figure 13 shows the magnitude and direction of the corresponding velocity vectors. Table 3 lists the velocities for the depth of eight feet with both circulating water pumps operating at design flow. Figure 14 shows the magnitude and direction of the corresponding velocity vectors. Table 4 lists the velocities for a depth of sixteen feet with both pumps at design flow. Figure 15 shows the corresponding velocity vectors.

The next test sequence involved the velocities resulting from operating the North pump only and at design flow. Table 5 lists the resulting velocities at a depth of two feet. Figure 16 shows the magnitude and direction of the corresponding velocity vectors. Table 6 lists the velocities at a depth of eight feet. Figure 17 shows the magnitude and direction of the corresponding velocity vectors. Table 7 lists the velocities at a depth of sixteen feet. Figure 18 shows the corresponding velocity vectors.

The third test sequence reports on velocity patterns resulting from the operating of the Center pump only and at design flow. Thus, Table 8 lists the velocities at a depth of two feet measured under this pumping mode. Figure 19 shows the corresponding velocity vectors. Table 9 lists the velocities at a depth of eight feet, and Figure 20 shows the corresponding velocity vectors. Table 10 lists the velocities at a depth of sixteen feet, and Figure 21 shows the corresponding velocity vectors.

Additional test sequences involoved model operations at discharges in excess of the design flows. Because of limitation of the laboratory pumps' capacities, somewhat varied flow rates were used. The North pump had a maximum flow rate of 650 cfs, and the Center pump had a maximum flow rate of 730 cfs. For the test series involving both circulating water pumps, an elevated flow rate of approximately 125 percent of design flow was used. When only the North pump was operated, the flow was 650 cfs. When only the Center pump was operated, the flow rate was at its maximum flow rate of 730 cfs. The test results are presented below.

Thus, results are first presented with both circulating water pumps operated at about 125 percent of design flow. Table 11 lists the velocities in the return channel at a depth of two feet. Figure 22 shows the magnitude and direction of the corresponding vectors. Table 12 lists the velocities at a depth of eight feet. Figure 23 shows the corresponding vectors. Table 13 lists the velocities at a depth of sixteen feet, and Figure 24 shows the corresponding vectors.

The next test sequence investigated was the velocity distributions with only the North pump in operation. As indicated above, the maximum flow rate for that pump was 650 cfs. Table 14 lists the velocities at a depth of two feet. Figure 25 shows the corresponding vectors in the return channel. Table 15 lists the velocities at a depth of eight feet and Figure 26 shows the corresponding vectors. Table 16 lists the velocities at a depth of sixteen feet, and Figure 27 shows the corresponding vectors.

The last test sequence involved operation of the Center pump only. The flow rate was at its maximum capacity of some 732 cfs. Table 17 lists the velocities at a depth of two feet. Figure 28 shows the corresponding vectors. Table 18 lists the velocities at a depth of eight feet. Figure 29 shows the corresponding velocity vectors. Table 19 lists the velocities at a depth of sixteen feet, and Figure 30 shows the corresponding vectors.

Pump Bell Flow Patterns

Twelve one-sixteenth inch diameter brass rods were inserted into the model floor around each suction bell. Each rod was occupying an hourly position, with the twelve o'clock position being at the rear wall of each pump bay. Colored tufts were mounted on each rod at three different elevations. These positions corresponded to prototype distances of 16 inches, 40 inches and 60 inches above the floor of the intake structure. The pump bell lips were located some 0.3 bell diameters, or 36 inches, above the floor. Observations were from above the model as well as through the plexiglass windows. The results are presented in a number of vector diagrams.

In the interpretation of the diagrams, it is important to recognize that only the horizontal directions of the velocity vectors are indicated. As shown in the legends given on each diagram, the magnitude of the vectors refers only to the elevation of the tufts above the floor of the intake structure. Thus, Figures 31 and 32 represent the flow directions near the suction bells in the North and Center bays when both circulating water pumps were operated at design flows. Figure 33 shows the flow pattern at the North pump suction bell when only the North pump is in operation. Similarly, Figure 34 shows the flow pattern at the Center pump suction bell when only the Center pump was in operation. Generally, the tufts indicated steady flow conditions. When unsteady or wavy flow patterns were observed, the directional vectors are presented in a dashed format.

Figures 35 and 36 represent the flow directions at the suction bells in the North and Center bays when both circulating water pumps were operated at some 125 percent of design flow. Similarly, Figures 37 and 38 show flow patterns near the suction bells when only one of the pumps was operated at a time and at an elevated flow rate.

Prerotation in Suction Lines

The results of studies of prerotation in the suction lines of the Plant Vogtle model are presented next. One vortimeter was installed in each suction line at an elevation above the rim of the intake structure model. Tables 20 through 23 list sets of twenty data for each test run. The two assemblies of suction lines and suction bells, each containing one vortimeter, were placed alternately under the North and Center pumps for ten sets of observations. This procedure was selected in an effort to eliminate a possible bias in the results from different sensitivities of the vortimeters.

Table 20 lists the results for test runs when both circulating water pumps were operated at design flow rates. Table 21 lists the results for the two seperate test conditions in which only the North pump or only the Center pump was operated at the design flow rate.

As was reported previously, these studies were also repeated for elevated flow rates. Thus, Table 22 lists the results for tests runs when both circulating water pumps were operated at about 125 percent of the design flow. Actually, the Center pump was operated at 677 cfs and the North pump was operated at

650 cfs. Table 23 lists again two separate test conditions in which only the North pump or only the Center pump was operated at the elevated flow rates.

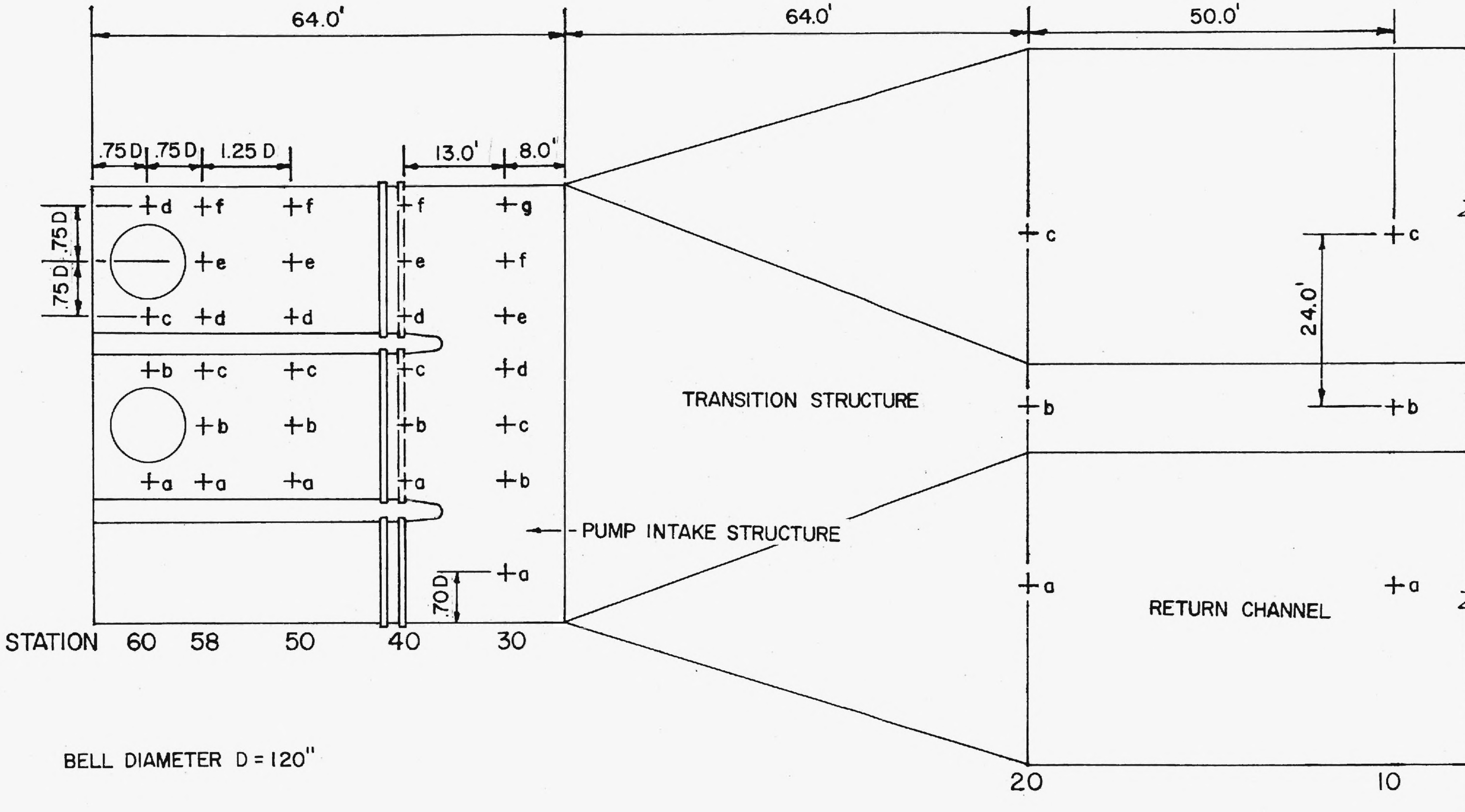


FIGURE 12. VELOCITY MEASURING STATIONS IN
1:8 HYDRAULIC MODEL

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 2. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	1.6	5°L	The following are taken at an equivalent depth of 2 feet below water surface. (**)
10b	0.9	Downstream	
10c	1.5	Downstream	
20a	1.7	5°L	Design flow, Q = 542 cfs.
20b	0.8	Downstream	
20c	1.4	Downstream	
30a	0.5	45°R	
30b	1.0	30°R	
30c	0.8	30°R	
30d	0.6	10°R	
30e	0.8	5°R	
30f	0.9	30°L	
30g	1.0	Downstream	
40a	0.9	Downstream	
40b	1.3	10°R	
40c	0.8	Downstream	
40d	1.1	Downstream	
40e	1.1	5°R	
40f	0.8	Downstream	
50a	0.9		Small eddy
50b	1.2	Downstream	
50c	1.1	Downstream	
50d	0.8	Downstream	
50e	1.0	Downstream	
50f	0.9	Downstream	
58a	0.8	Downstream	
58b	0.8	Downstream	
58c	0.6	Downstream	
58d	0.6	Downstream	
58e	0.6	5°L	
58f	0.8	Downstream	

(*) See definition sketch
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 2. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments(**)
60a	0.6	Downstream	
60b	0.8	Downstream	
60c	0.5	Downstream	
60d	0.9	Downstream	

(*) See definition sketch
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

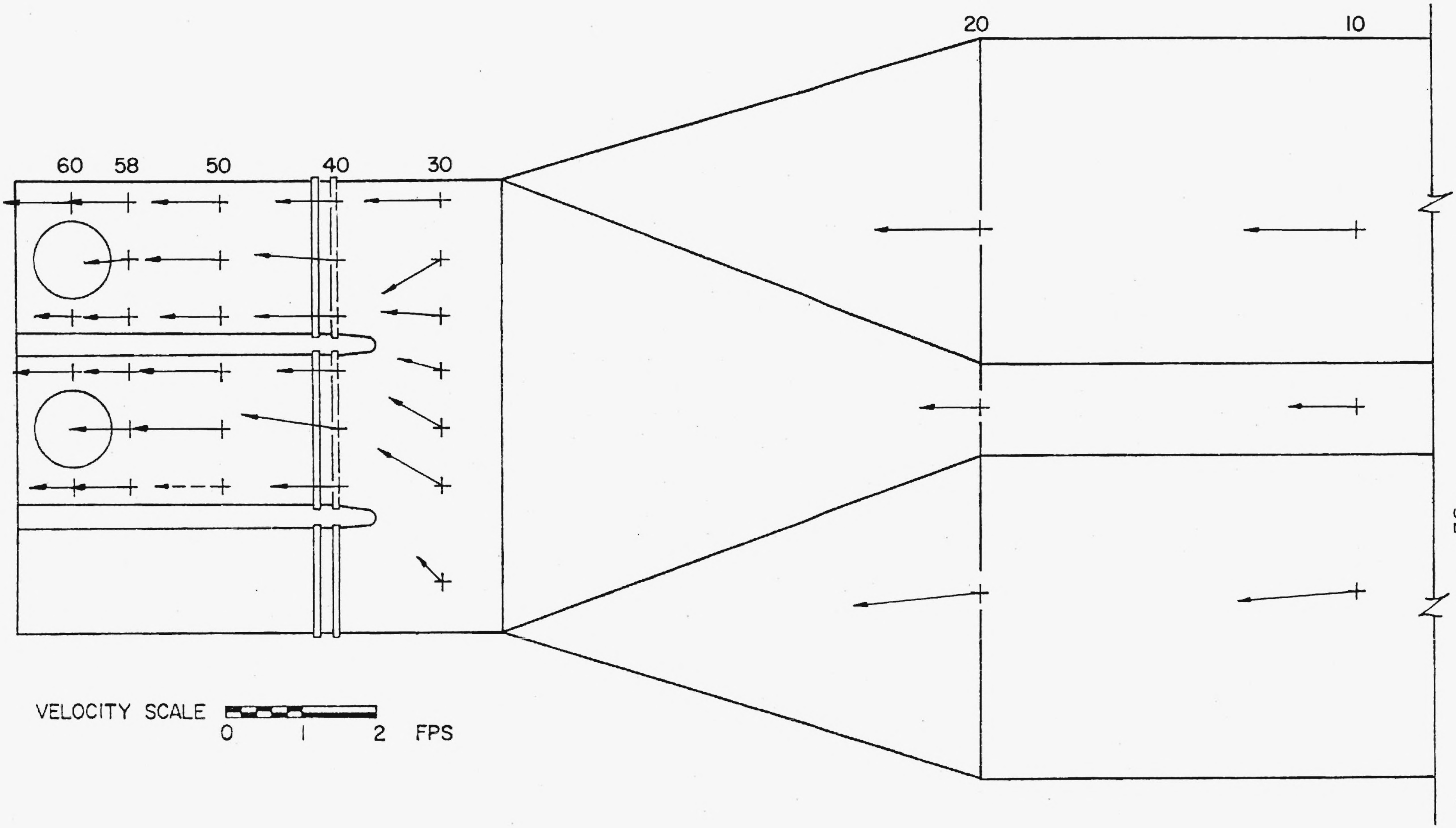


FIGURE 13. APPROACH VELOCITIES AT ELEVATION 212, PUMP FLOW RATE 542 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 3. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	0.6	Downstream	The following are taken at an equivalent depth of 8 feet below water surface. (**)
20b	0.7	5°R	
30a	0.7	45°R	Design flow, Q = 542 cfs.
30b	1.0	40°R	
30c	0.8	30°R	
30d	0.6	5°R	
30e	0.8	5°R	
30f	0.9	Downstream	
30g	1.0	Downstream	
40a	1.2	Downstream	
40b	1.1	5°R	
40c	0.8	Downstream	
40d	1.0	Downstream	
40e	1.0	Downstream	
40f	1.1	Downstream	
50a	0.8	Downstream	
50b	1.2	Downstream	
50c	1.1	5°L	
50d	0.8	Downstream	
50e	1.0	Downstream	
50f	1.1	Downstream	
58a	0.8	Downstream	
58b	0.8	Downstream	
58c	0.9	Downstream	
58d	0.8	Downstream	
58e	0.7	Downstream	
58f	0.8	Downstream	
60a	1.0	Downstream	
60b	0.9	Downstream	
60c	0.7	5°R	
60d	1.1	Downstream	

(*) See definition sketch.
(**) Water surface elvation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

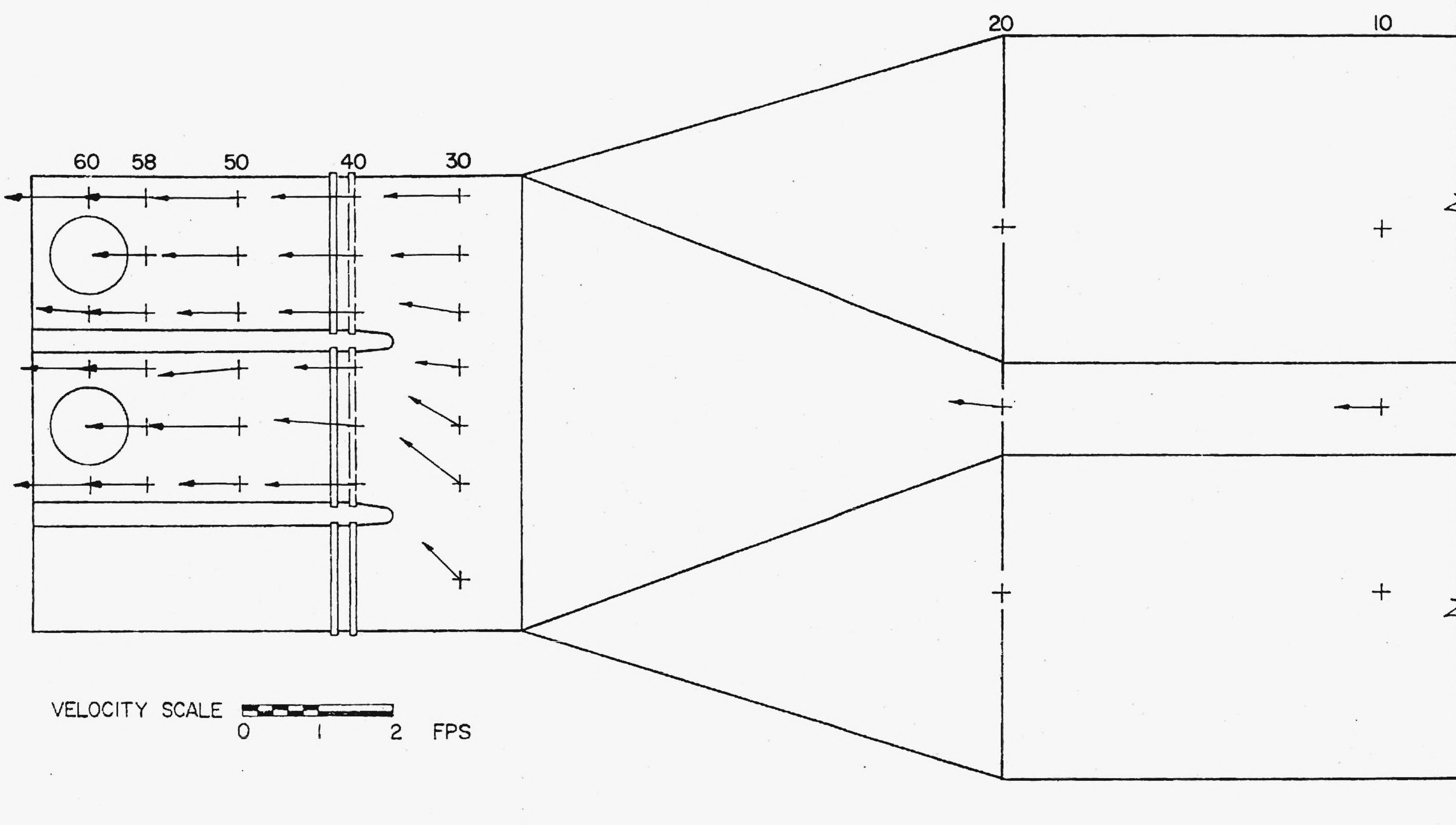


FIGURE 14. APPROACH VELOCITIES AT ELEVATION 206, PUMP FLOW RATE 542 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 4. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
30a	0.8	45°R	The following are taken at an equivalent depth of 16 feet below water surface. (**)
30b	0.9	45°R	
30c	0.7	Downstream	
30d	0.5	5°L	
30e	0.6	10°R	Design flow, Q = 542 cfs.
30f	0.8	Downstream	
30g	1.0	Downstream	
40a	1.7	5°R	
40b	1.1	Downstream	
40c	0.7	10°L	
40d	1.1	Downstream	
40e	0.9	Downstream	
40f	1.1	Downstream	
50a	0.9	Downstream	
50b	1.3	Downstream	
50c	1.3	5°L	
50d	1.0	Downstream	
50e	1.2	Downstream	
50f	1.2	Downstream	
58a	1.2	5°L	
58b	1.2	Downstream	
58c	1.4	Downstream	
58d	1.1	Downstream	
58e	1.1	Downstream	
58f	1.4	Downstream	
60a	1.4	Downstream	
60b	1.5	5°L	
60c	1.2	15°R	
60d	1.8	5°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

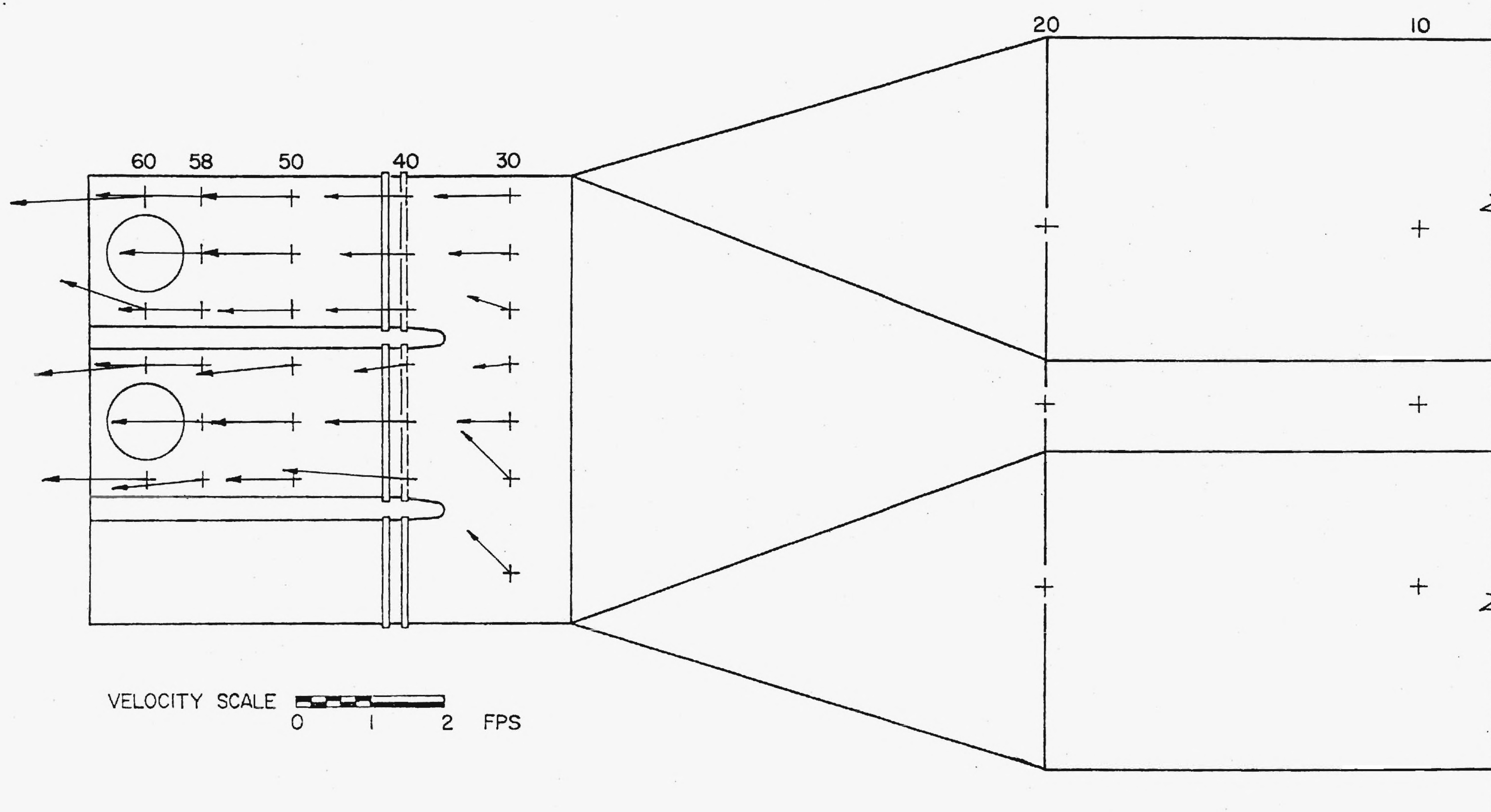


FIGURE 15. APPROACH VELOCITIES AT ELEVATION 198, PUMP FLOW RATE 542 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 5. Velocities in Approach Channel
in 1:8 Scale Model
North Bay Pump Only
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	0.7	Downstream	The following are taken at an
10b	0.6	Downstream	equivalent depth of 2 feet
10c	0.9	Downstream	below water surface. (**)
20a	0.5	Downstream	Design flow = 542 cfs.
20b	0.2	Downstream	
20c	0.9	Downstream	
30a	0.1	15°R	
30b	0.0		No flow.
30c	0.1	45°R	
30d	0.3	45°R	
30e	0.6	15°R	
30f	0.8	15°R	
30g	0.9	Downstream	
40a	0.0		No flow.
40b	0.1	45°R	
40c	0.0		No flow.
40d	1.5		No definite direction.
40e	1.2	15°R	
40f	1.3	Downstream	
50a	0.0		No flow.
50b	0.0		No flow.
50c	0.0		No flow.
50d	0.9		No definite direction.
50e	1.3	5°R	
50f	1.4	Downstream	
58d	0.4	5°L	
58e	0.7	Downstream	
58f	1.0	Downstream	
60c	0.5	Downstream	
60d	0.8	5°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

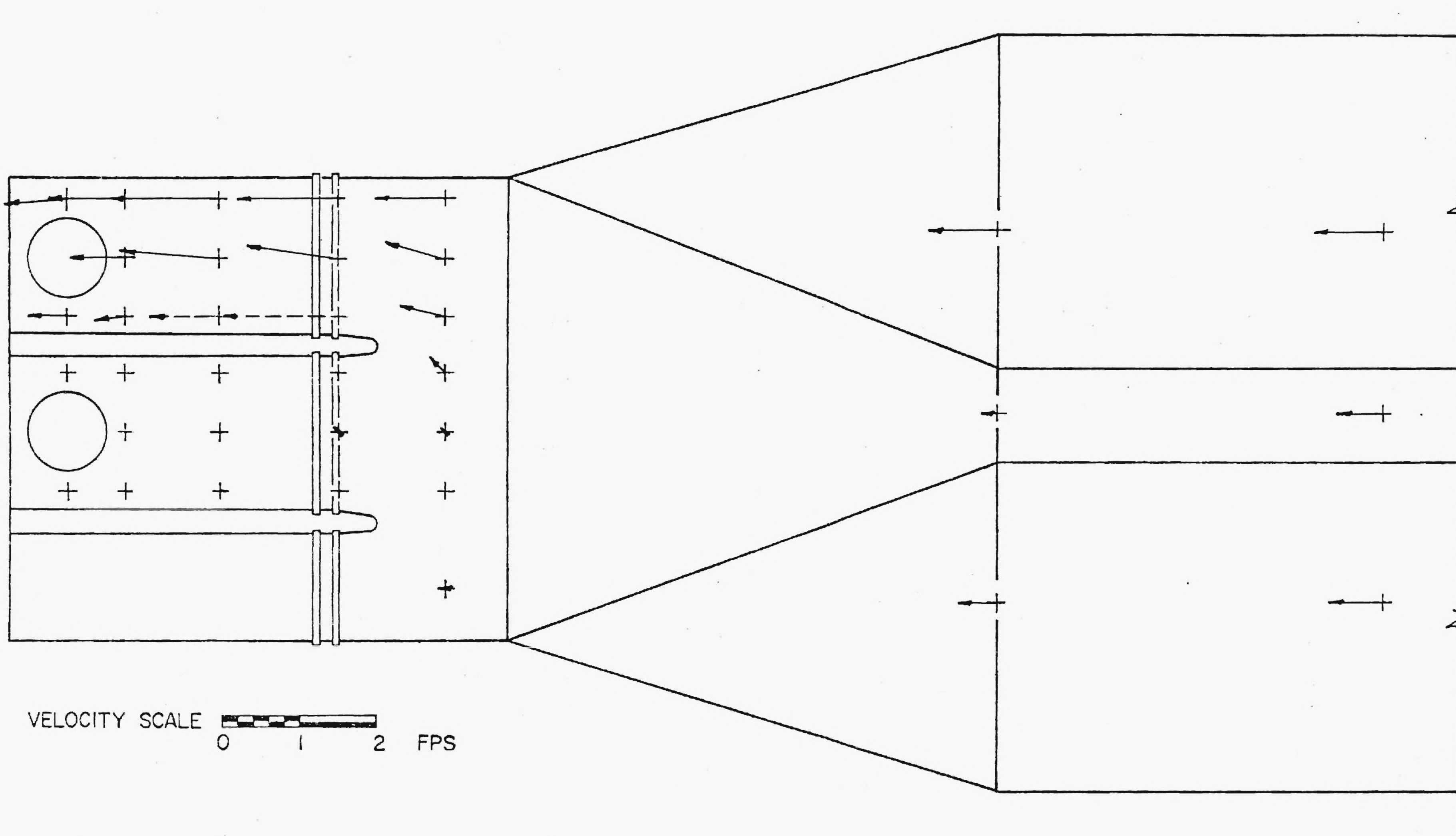


FIGURE 16. APPROACH VELOCITIES AT ELEVATION 212, PUMP FLOW RATE 542 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 6. Velocities in Approach Channel
in 1:8 Scale Model
North Bay Pump Only
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	0.2	Downstream	The following are taken at an equivalent depth of 8 feet
20b	0.4	Downstream	below water surface. (**)
30a	0.2	10°R	Design flow, Q =542 cfs.
30b	0.0		No flow.
30c	0.0	60°R	
30d	0.2	70°R	
30e	0.6	45°R	
30f	0.8	15°R	
30g	0.9	Downstream	
40a	0.0		No flow.
40b	0.0		No flow.
40c	0.0		No flow.
40d	1.4		No definite direction.
40e	1.2	Downstream	
40f	1.3	Downstream	
50a	0.0		No flow.
50b	0.0		No flow.
50c	0.0		No flow.
50d	0.9		No definite direction.
50e	1.3	Downstream	
50f	1.4	Downstream	
58d	1.1	5°L	
58e	0.8	5°R	
58f	0.9	Downstream	
60c	0.9	Downstream	
60d	1.2	15°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

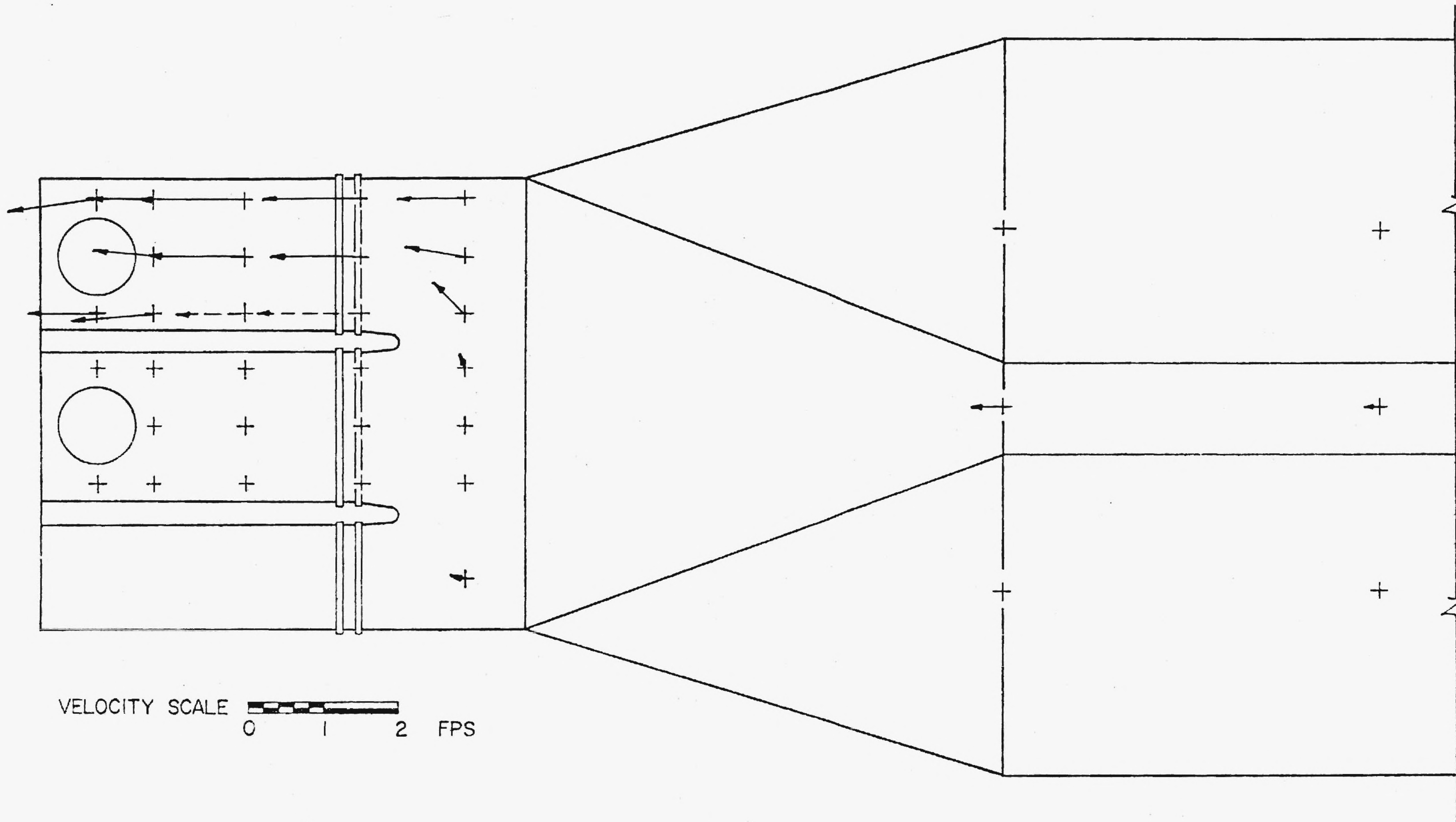


FIGURE 17. APPROACH VELOCITIES AT ELEVATION 206, PUMP FLOW RATE 542 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 7. Velocities in Approach Channel in 1:8 Scale Model North Bay Pump Only Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
30a	0.2	90°R	The following are taken at an equivalent depth of 16 feet below water surface. (**)
30b	0.2	90°R	
30c	0.1	90°R	
30d	0.3	45°R	
30e	0.6	15°R	Design flow, Q = 542 cfs.
30f	0.7	Downstream	
30g	0.9	Downstream	
40a	0.0		No flow.
40b	0.0		No flow.
40c	0.0		No flow.
40d	0.5	30°R	
40e	1.3	Downstream	
40f	1.0	Downstream	
50a	0.0		No flow.
50b	0.0		No flow.
50c	0.0		No flow.
50d	0.5		No definite direction.
50e	1.3	5°L	
50f	1.3	Downstream	
58d	1.3	5°R	
58e	1.0	5°R	
58f	1.5	Downstream	
60c	1.3	30°R	
60d	1.7	45°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

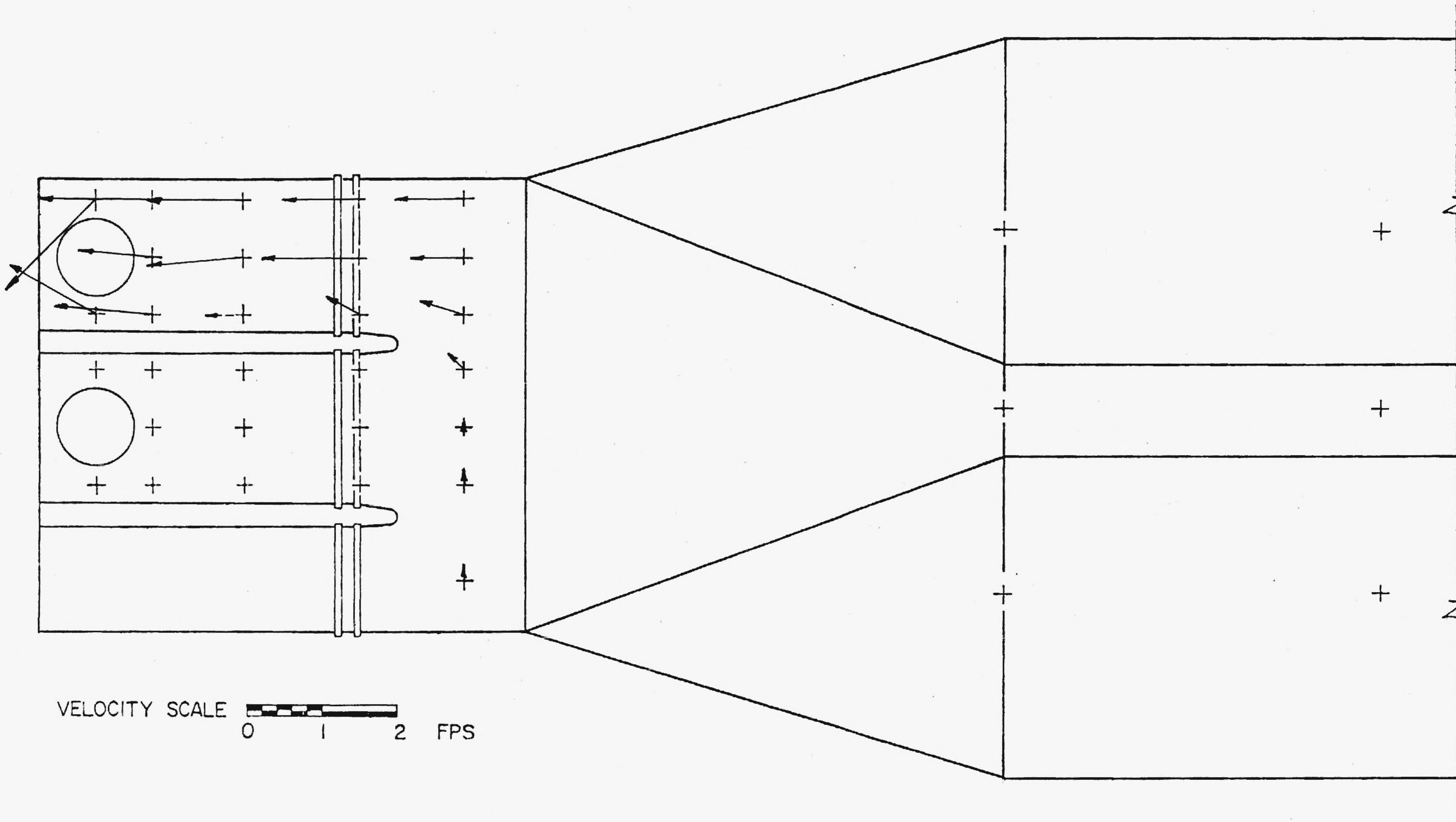


FIGURE 18. APPROACH VELOCITIES AT ELEVATION 198,
PUMP FLOW RATE 542 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 8. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	0.7	Downstream	The following are taken at an
10b	0.6	Downstream	equivalent depth of 2 feet below
10c	0.6	Downstream	water surface. (**)
20a	0.6	Downstream	Design flow, Q = 542 cfs.
20b	0.3	Downstream	Mixing.
20c	0.8	Downstream	
30a	0.2		No definite direction.
30b	0.5	10°R	
30c	0.4	Downstream	
30d	0.3	30°L	
30e	0.1	45°L	
30f	0.1	Downstream	
30g	0.0	Upstream	
40a	1.2	Downstream	
40b	1.0	Downstream	
40c	0.9		Eddy.
40d	0.1		No definite direction.
40e	0.0		No definite direction.
40f	0.0		No definite direction.
50a	1.0	Downstream	
50b	1.0	Downstream	
50c	0.6	Downstream	
58a	0.3	Downstream	
58b	0.7	Downstream	
58c	0.6	Downstream	
60a	0.6	Downstream	
60b	0.4	Downstream	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

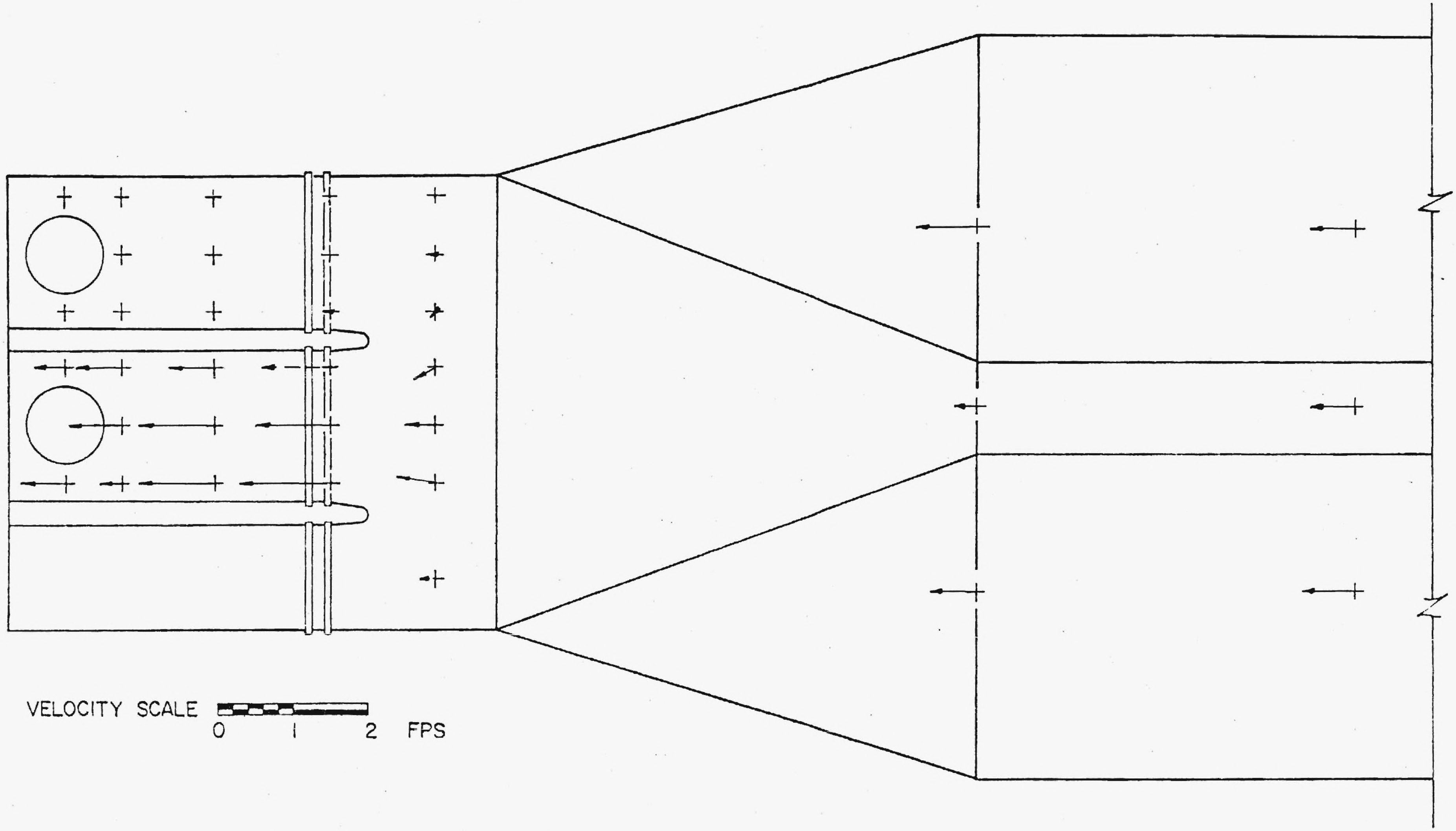


FIGURE 19. APPROACH VELOCITIES AT ELEVATION 212, PUMP FLOW RATE 542 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 9. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	0.2	Downstream	The following are taken at an equivalent depth of 8 feet below water surface. (**)
20b	0.4	Downstream	
30a	0.3	20°R	Design flow, Q = 542 cfs.
30b	0.4	5°R	
30c	0.5	Downstream	
30d	0.5	30°L	
30e	0.4	45°L	
30f	0.3		No definite direction.
30g	0.0		No definite direction.
40a	1.2	Downstream	
40b	1.0	10°R	
40c	1.2	Downstream	
40d	0.0		No definite direction.
40e	0.0		No definite direction.
40f	0.0		No definite direction.
50a	1.0	Downstream	
50b	1.1	Downstream	
50c	1.0	Downstream	
58a	1.0	Downstream	
58b	0.8	10°R	
58c	1.0	Downstream	
60a	0.9	Downstream	
60b	1.0	Downstream	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

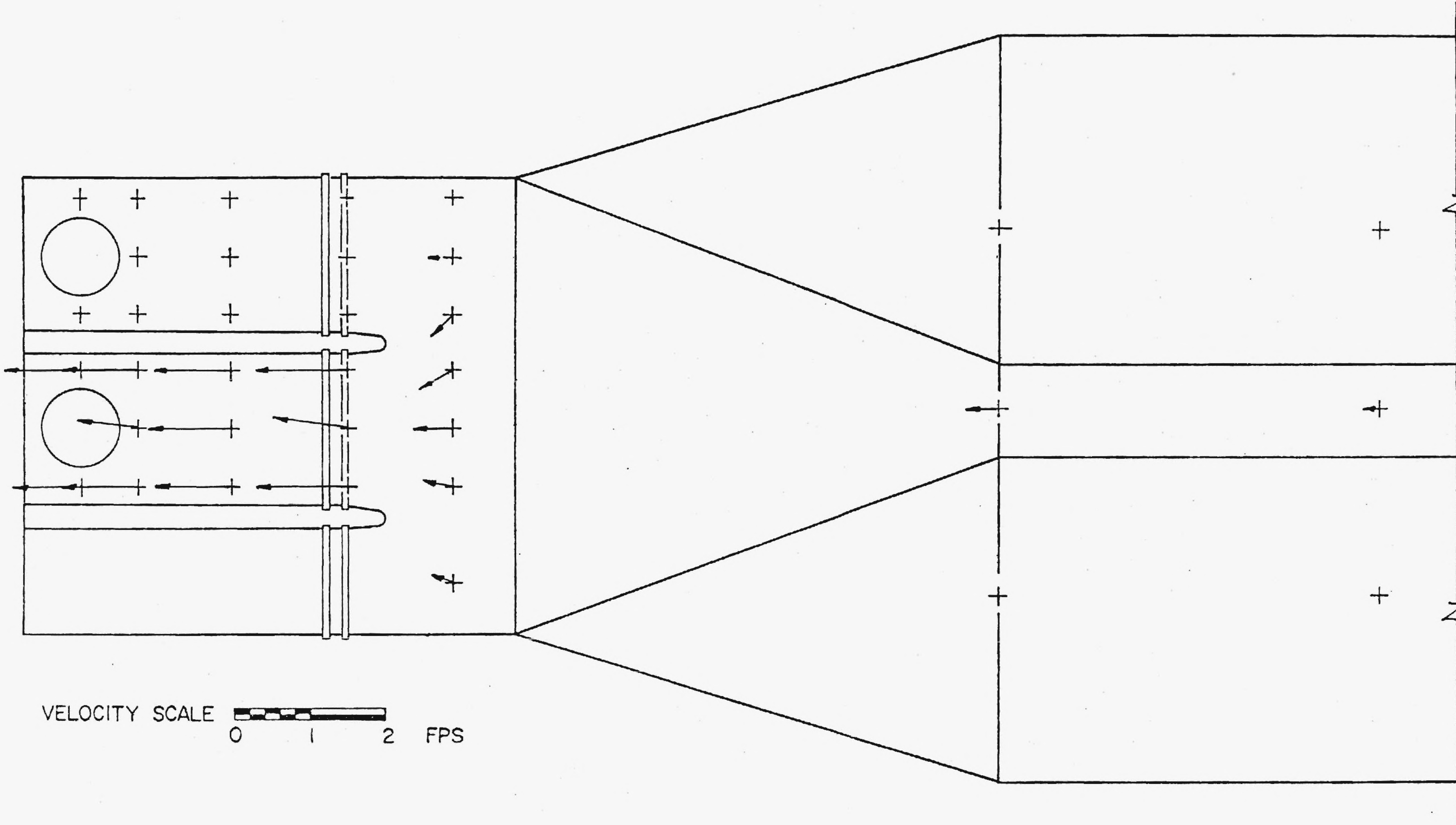


FIGURE 20. APPROACH VELOCITIES AT ELEVATION 206,
PUMP FLOW RATE 542 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 10. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
30a	0.2	30°R	The following are taken at an equivalent depth of 16 feet below water surface. (**)
30b	0.4	5°R	
30c	0.6	Downstream	
30d	0.6	10°L	
30e	0.5	80°L	Design flow, Q = 542 cfs.
30f	0.1		No definite direction.
30g	0.0		No definite direction.
40a	1.2	Downstream	
40b	1.0	Downstream	
40c	1.4	Downstream	
40d	0.0		No definite direction.
40e	0.0		No definite direction.
40f	0.0		No definite direction.
50a	1.2	Downstream	
50b	1.2	Downstream	
50c	1.2	Downstream	
58a	1.3	Downstream	
58b	1.1	Downstream	
58c	1.2	Downstream	
60a	1.5	15°R	
60b	1.3	15°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

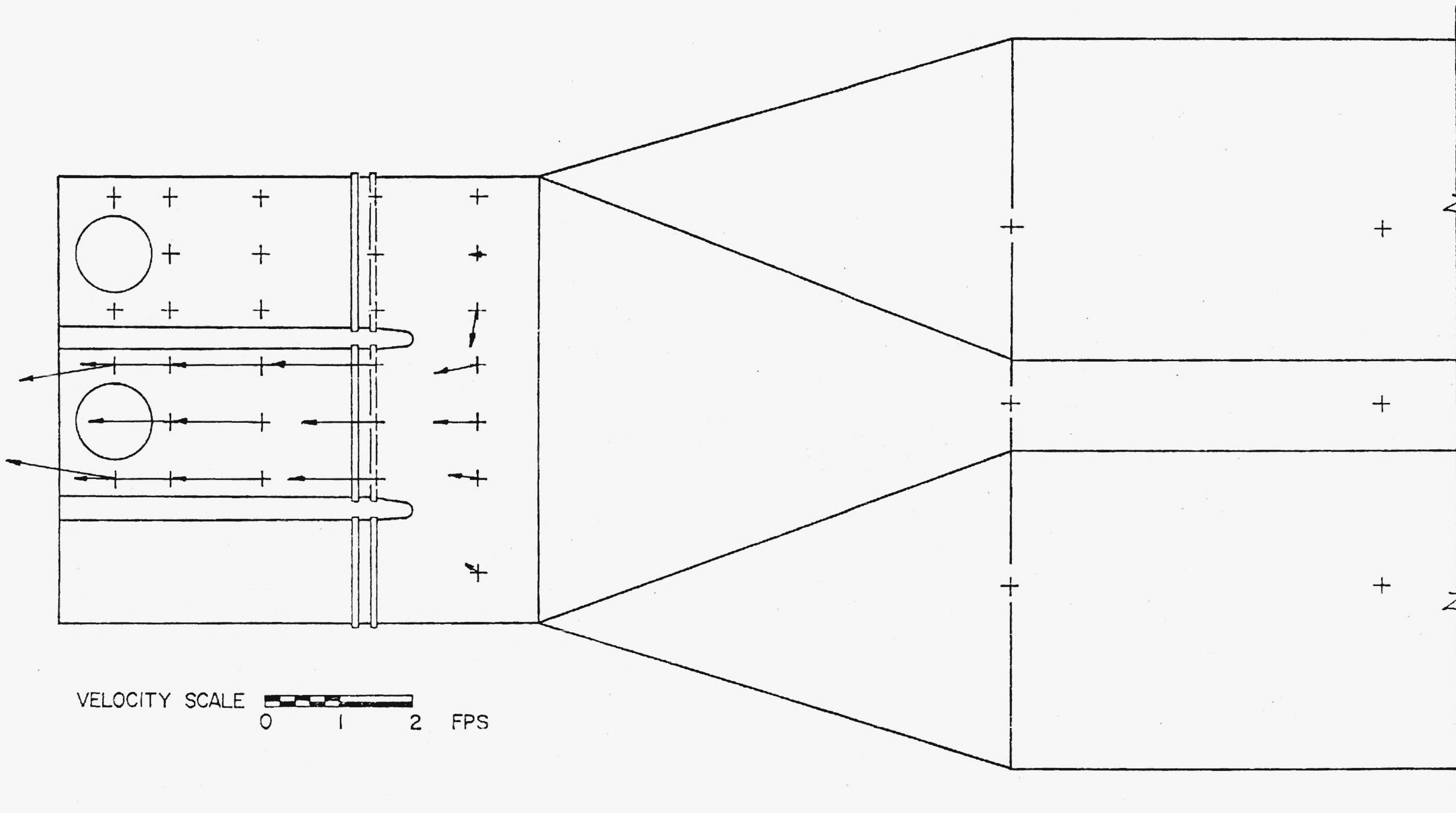


FIGURE 21. APPROACH VELOCITIES AT ELEVATION 198, PUMP FLOW RATE 542 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 11. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
At 125% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	1.9	Downstream	The following are taken at an
10b	1.4	Downstream	equivalent depth of 2 feet
10c	1.9	Downstream	below water surface. (**)
20a	2.1	5°L	Center pump, Q = 677 cfs.
20b	1.0	Downstream	North pump, Q = 650 cfs.
20c	1.8	Downstream	
30a	0.8	60°R	
30b	1.0	45°R	
30c	0.8	15°R	
30d	0.7	10°R	
30e	0.8	10°R	
30f	1.1	Downstream	
30g	1.3	Downstream	
40a	1.8	15°R	
40b	1.4	Downstream	
40c	1.3	Downstream	
40d	1.1	Downstream	
40e	1.1	Downstream	
40f	1.1	Downstream	
50a	1.1		Eddy.
50b	1.4	Downstream	
50c	1.3	Downstream	
50d	0.8	Downstream	
50e	1.1	Downstream	
50f	1.2	Downstream	
58a	0.8	Downstream	
58b	0.7	30°L	
58c	1.0	5°L	
58d	0.7	15°L	
58e	0.5	30°R	
58f	1.0	Downstream	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 11. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
At 125% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments(**)
60a	0.8	Downstream	
60b	1.0	Downstream	
60c	0.5	5°L	
60d	1.2	Downstream	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

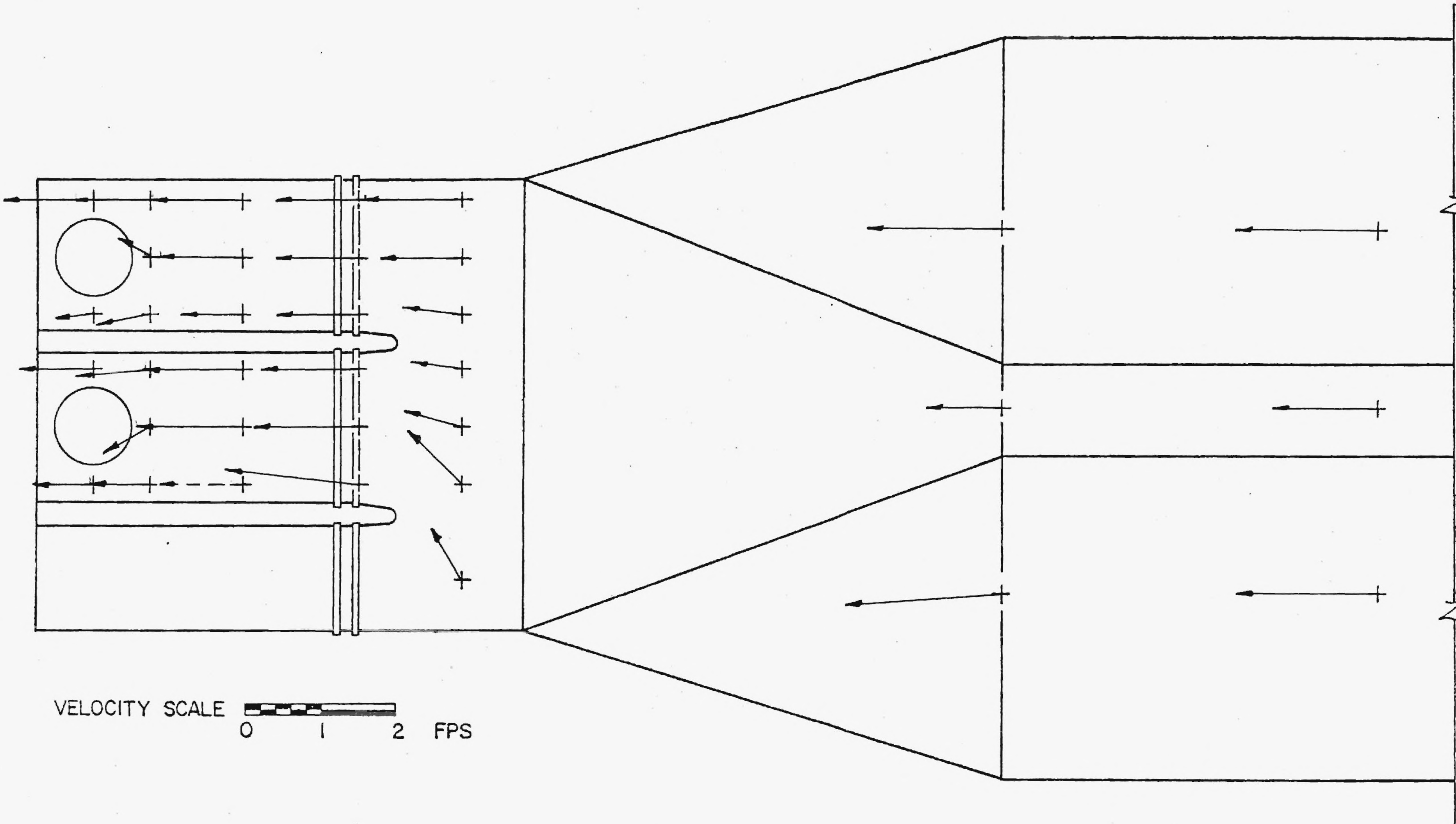


FIGURE 22. APPROACH VELOCITIES AT ELEVATION 212,
PUMP FLOW RATE 677 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 12. Velocities in Approach Channel
in 1:8 Scale Model
All Pumps Operating
At 125% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	1.0	Downstream	The following are taken at an equivalent depth of 8 feet below water surface. (**)
20b	1.0	Downstream	
30a	1.0	45°R	Center pump, Q = 677 cfs.
30b	0.9	30°R	North pump, Q = 650 cfs.
30c	0.8	10°R	
30d	0.7	Downstream	
30e	0.8	15°R	
30f	1.1	Downstream	
30g	1.5	Downstream	
40a	2.1	10°R	
40b	1.4	Downstream	
40c	1.2	5°L	
40d	1.1	5°R	
40e	1.3	Downstream	
40f	1.4	Downstream	
50a	1.3		Eddy.
50b	1.6	Downstream	
50c	1.4	5°L	
50d	0.8	Downstream	
50e	1.2	Downstream	
50f	1.6	Downstream	
58a	1.1	Downstream	
58b	0.8	15°L	
58c	1.2	Downstream	
58d	0.8	Downstream	
58e	0.7	Downstream	
58f	1.1	Downstream	
60a	1.2	Downstream	
60b	1.3	5°L	
60c	0.8	Downstream	
60d	1.3	Downstream	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

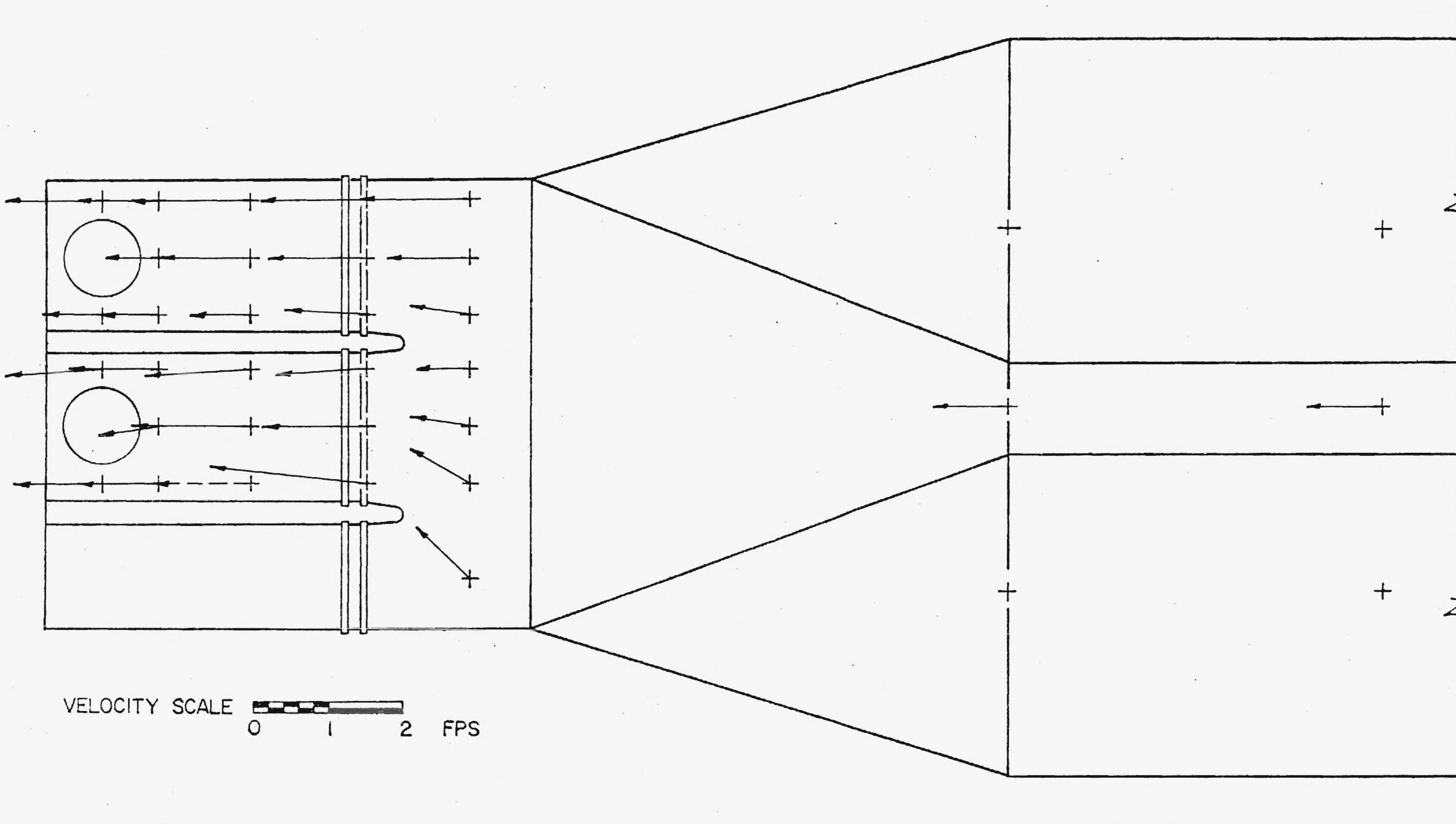


FIGURE 23. APPROACH VELOCITIES AT ELEVATION 206,
PUMP FLOW RATE 677 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 13. Velocities in Approach Channel in 1:8 Scale Model All Pumps Operating At 125% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
30a	0.9	45°R	The following are taken at an equivalent depth of 16 feet below water surface. (**)
30b	1.0	30°R	
30c	0.7	20°R	
30d	0.6	5°L	
30e	0.9	5°R	Center pump, Q = 677 cfs.
30f	1.1	Downstream	North pump, Q = 650 cfs.
30g	1.4	Downstream	
40a	2.2	10°R	
40b	1.4	Downstream	
40c	1.2	5°L	
40d	1.0	5°R	
40e	1.2	Downstream	
40f	1.4	Downstream	
50a	0.9		Eddy.
50b	1.7	Downstream	
50c	1.6	10°L	
50d	1.1	Downstream	
50e	1.3	Downstream	
50f	1.5	Downstream	
58a	1.4	20°R	
58b	1.5	Downstream	
58c	1.8	Downstream	
58d	1.3	Downstream	
58e	1.3	Downstream	
58f	1.6	Downstream	
60a	1.7	45°R	
60b	1.9	30°L	
60c	1.4	45°R	
60d	2.0	10°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

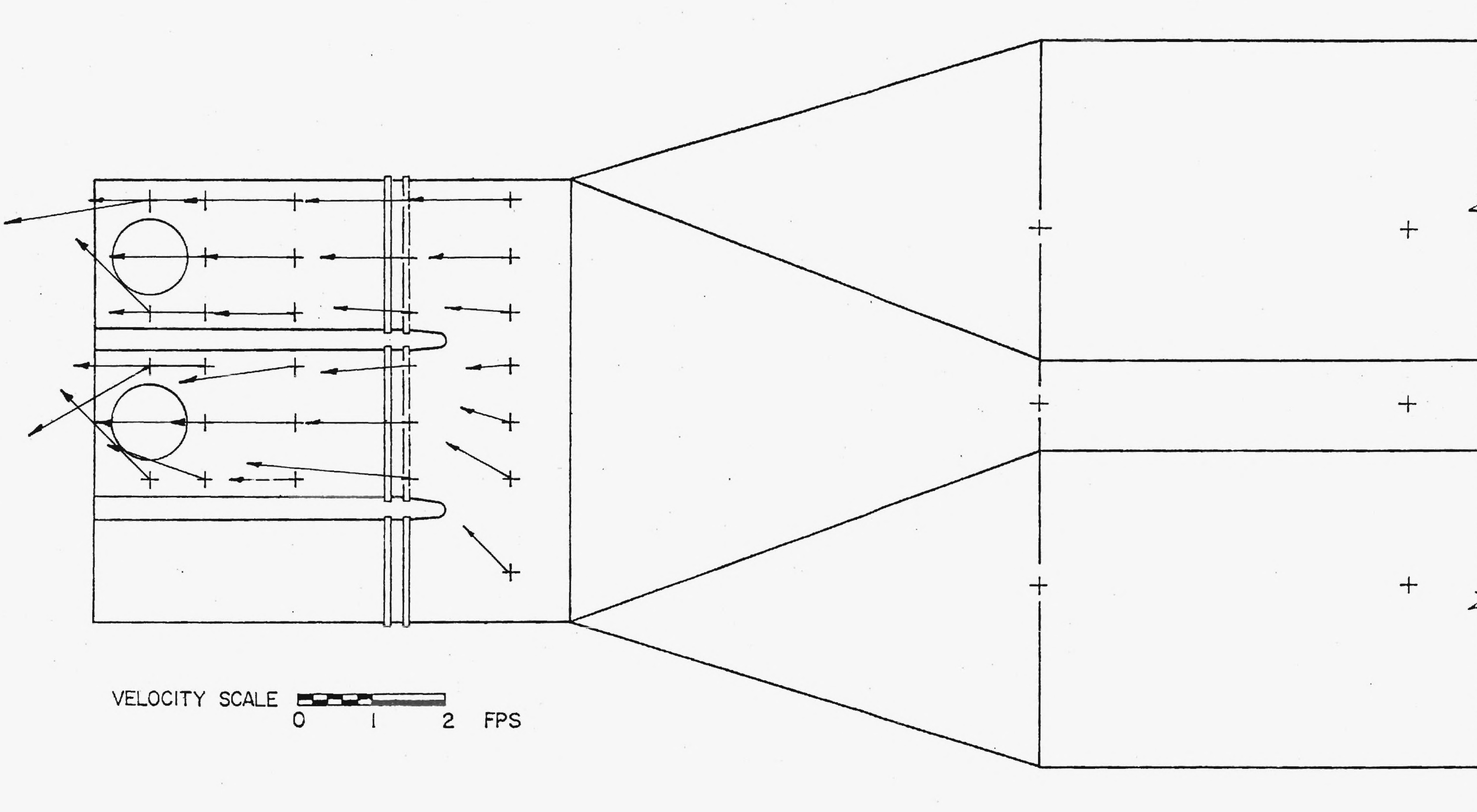


FIGURE 24. APPROACH VELOCITIES AT ELEVATION 198,
PUMP FLOW RATE 677 CFS IN NORTH AND CENTER PUMPS

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 14. Velocities in Approach Channel
in 1:8 Scale Model
North Bay Pump Only
At 120% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	0.7	Downstream	The following are taken at an
10b	0.6	Downstream	equivalent depth of 2 feet
10c	1.0	Downstream	below water surface. (**)
20a	0.6	10°L	North pump, Q = 650 cfs.
20b	0.5	5°R	
20c	1.0	Downstream	
30a	0.2		No definite direction.
30b	0.2	Downstream	
30c	0.2	10°R	
30d	0.4	45°R	
30e	0.7	15°R	
30f	0.8	10°R	
30g	1.0	Downstream	
40a	0.1		No definite direction.
40b	0.0	80°R	
40c	0.0	90°R	
40d	1.2	Downstream	
40e	1.2	Downstream	
40f	1.3	Downstream	
50a	0.0		No definite direction.
50b	0.0		No definite direction.
50c	0.0		No definite direction.
50d	0.8	Downstream	
50e	1.2	Downstream	
50f	1.3	Downstream	
58d	0.4	10°L	
58e	0.6	45°L	
58f	1.0	Downstream	
60c	0.5	Downstream	
60d	1.1	10°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

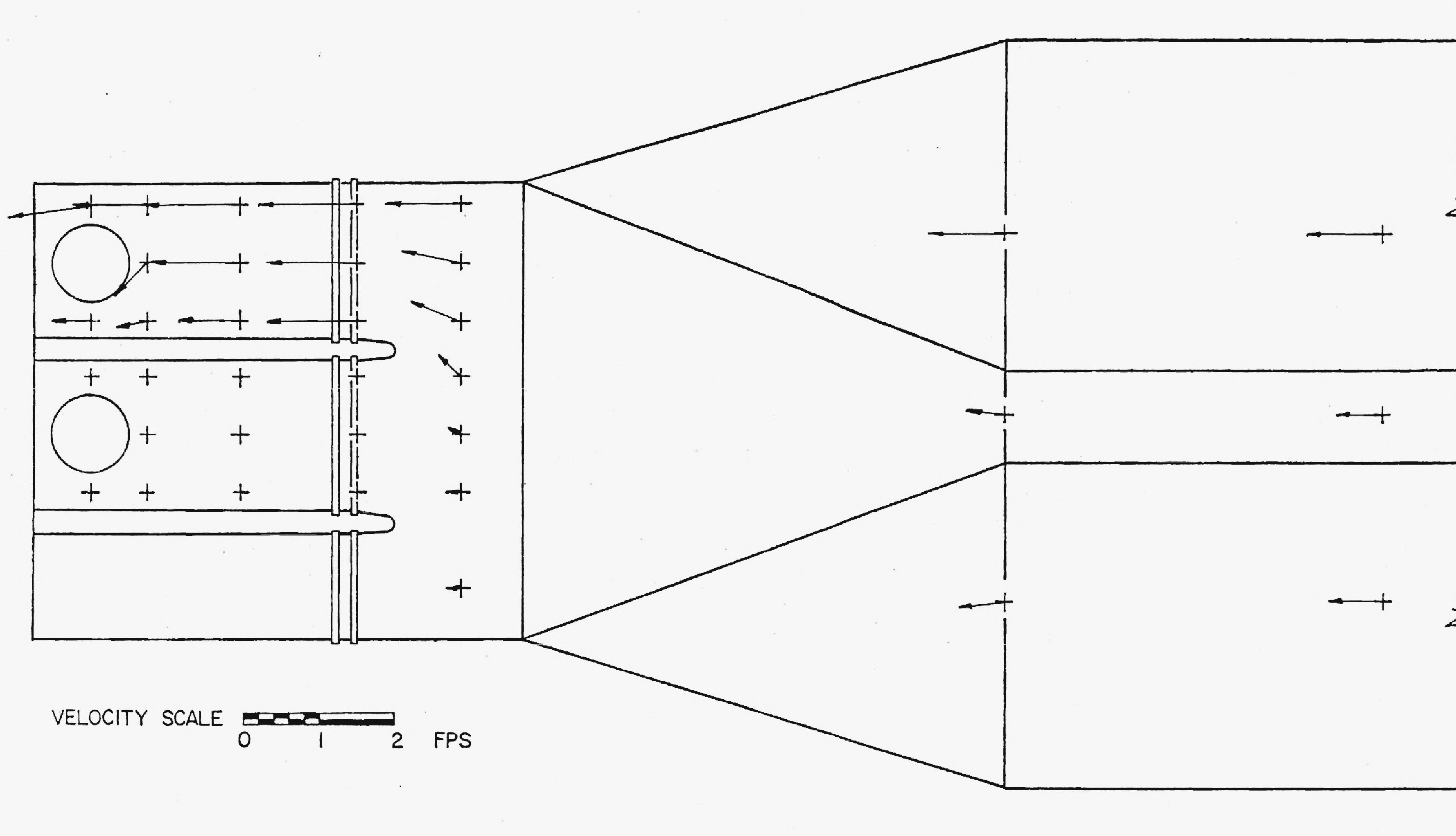


FIGURE 25. APPROACH VELOCITIES AT ELEVATION 212,
PUMP FLOW RATE 650 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 15. Velocities in Approach Channel
in 1:8 Scale Model
North Bay Pump Only
At 120% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	0.5	Downstream	The following are taken at an equivalent depth of 8 feet below water surface. (**)
20b	0.5	5°R	North pump, Q = 650 cfs.
30a	0.0		No flow.
30b	0.2	70°R	
30c	0.1	75°R	
30d	0.4	45°R	
30e	0.7	15°R	
30f	0.8	Downstream	
30g	1.1	Downstream	
40a	0.0	45°R	Very slow.
40b	0.1	90°R	
40c	0.1	100°R	Slightly upstream.
40d	1.4	Downstream	
40e	1.3	Downstream	
40f	1.4	Downstream	
50a	0.0		No definite direction.
50b	0.0		No definite direction.
50c	0.0		No definite direction.
50d	1.1	Downstream	
50e	1.3	Downstream	
50f	1.4	Downstream	
58d	0.9	Downstream	
58e	0.8	Downstream	
58f	1.1	Downstream	
60c	0.8	Downstream	
60d	1.3	45°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

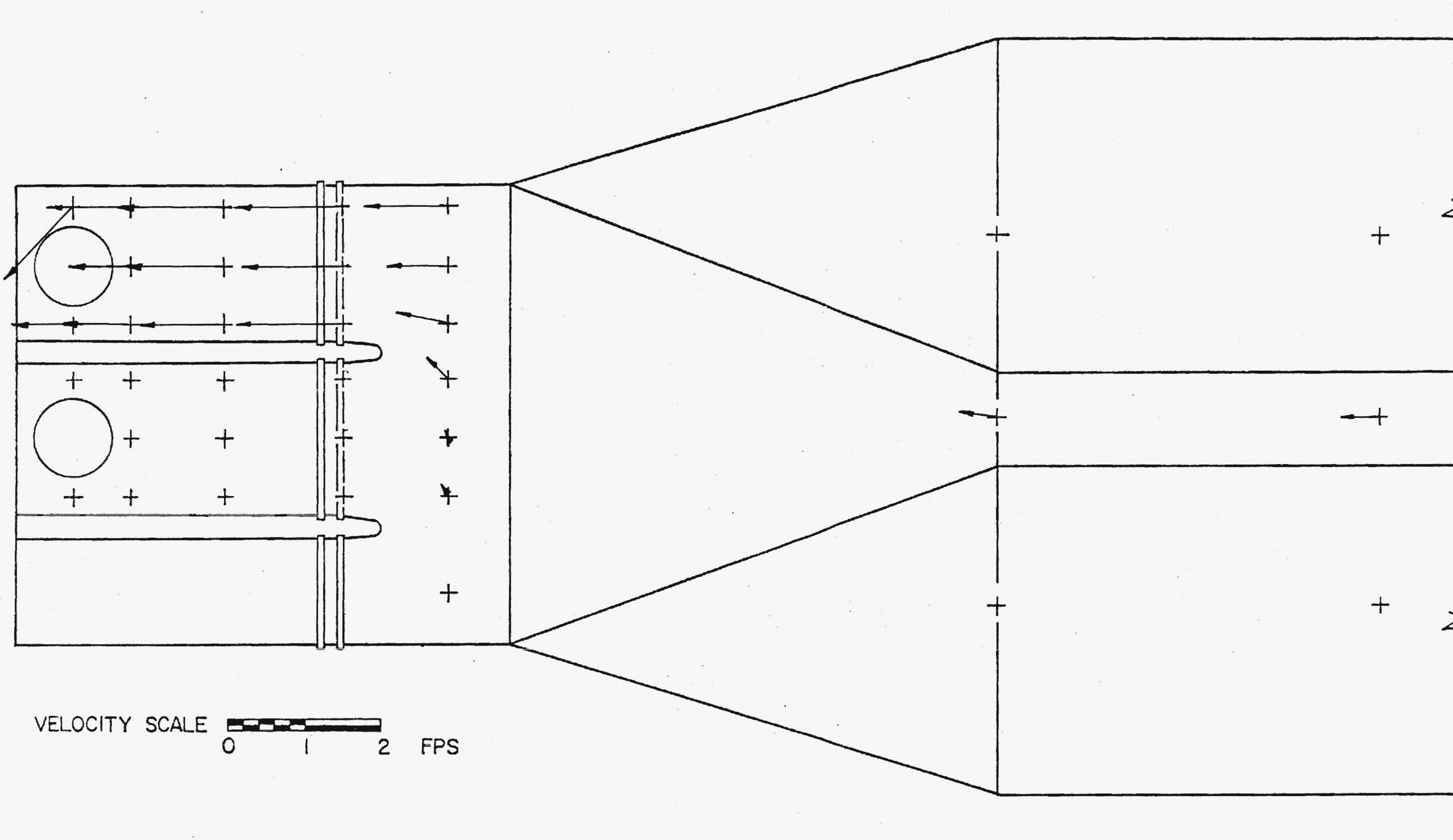


FIGURE 26. APPROACH VELOCITIES AT ELEVATION 206,
PUMP FLOW RATE 650 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 16. Velocities in Approach Channel
in 1:8 Scale Model
North Bay Pump Only
At 120% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
			The following are taken at an equivalent depth of 16 feet below water surface. (**)
			North pump, Q = 650 cfs.
30a	0.0	45°R	Very slow.
30b	0.1	90°R	
30c	0.2	90°R	
30d	0.3	15°R	
30e	0.7	10°R	
30f	0.8	Downstream	
30g	0.9	Downstream	
40a	0.0	90°R	Very slow.
40b	0.0	100°R	Slightly upstream.
40c	0.0	Upstream	
40d	1.3	45°R	
40e	1.3	Downstream	
40f	1.3	Downstream	
50a	0.0	Upstream	Very slow.
50b	0.0		No definite direction.
50c	0.0		No definite direction.
50d	1.0	20°R	
50e	1.5	Downstream	
50f	1.5	Downstream	
58d	1.4	Downstream	
58e	1.3	Downstream	
58f	1.6	Downstream	
60c	1.4	80°R	
60d	1.9	45°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

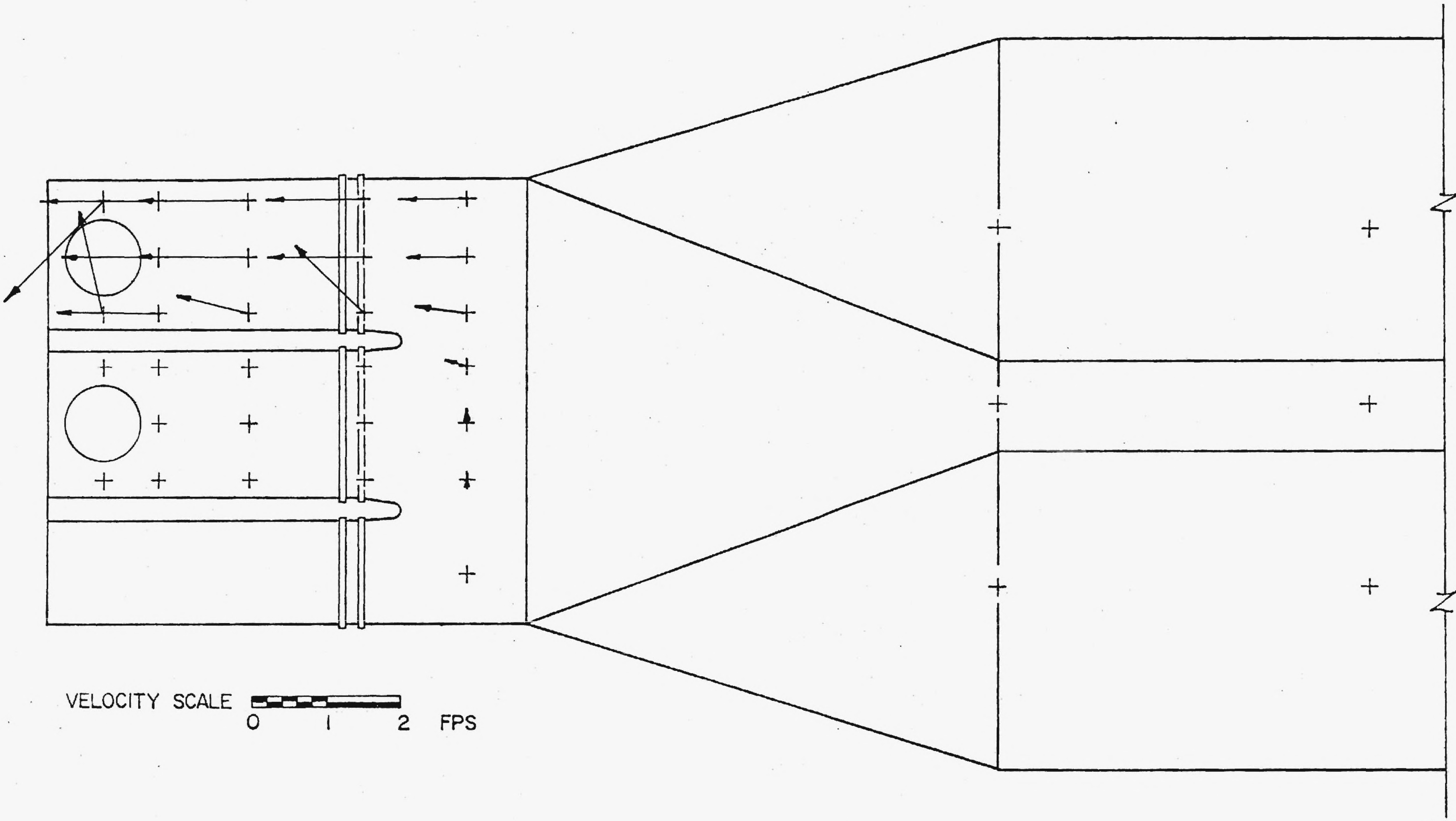


FIGURE 27. APPROACH VELOCITIES AT ELEVATION 198,
PUMP FLOW RATE 650 CFS IN NORTH PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 17. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
At 135% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10a	0.9	Downstream	The following are taken at an
10b	0.7	Downstream	equivalent depth of 2 feet
10c	1.0	Downstream	below water surface. (**)
20a	0.8	5°L	Center pump, Q = 732 cfs.
20b	0.4	Downstream	
20c	1.1	10°R	
30a	0.5	45°R	
30b	0.4	Downstream	
30c	0.5	Downstream	
30d	0.5	20°L	
30e	0.3	75°L	
30f	0.1		No definite direction.
30g	0.0		No definite direction.
40a	1.6	Downstream	
40b	1.5	Downstream	
40c	1.8	15°L	
40d	0.0	135°L	
40e	0.0	Upstream	
40f	0.1		No definite direction.
50a	1.3	Downstream	
50b	1.2	Downstream	
50c	0.7	Downstream	
50d	0.0		No definite direction.
50e	0.0		No definite direction.
50f	0.0		No definite direction.
58a	1.0	Downstream	
58b	0.7	Downstream	
58c	0.3	Downstream	
60a	1.0	Downstream	
60b	0.4	10°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

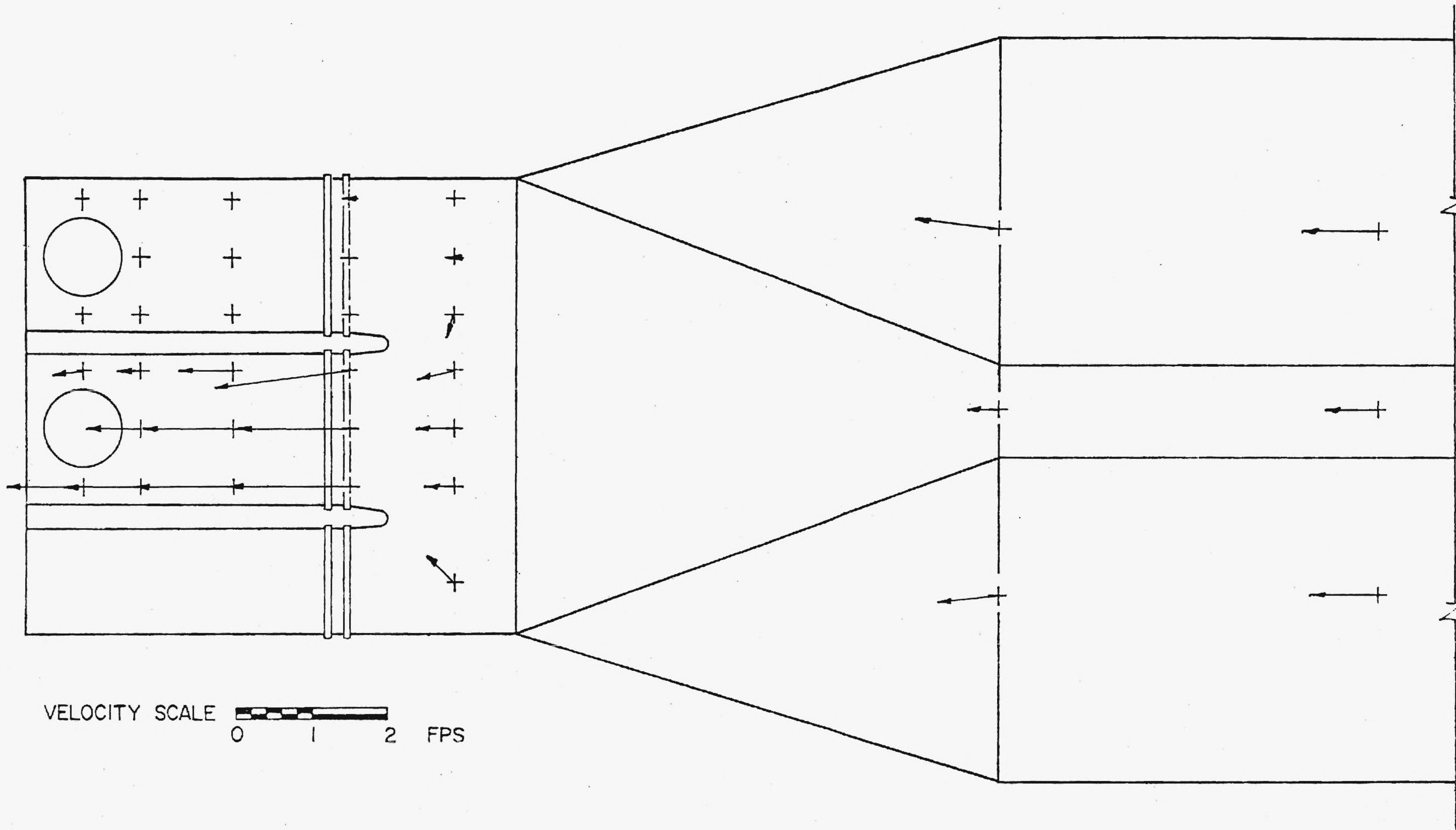


FIGURE 28. APPROACH VELOCITIES AT ELEVATION 212, PUMP FLOW RATE 732 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 18. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
At 135% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
10b	0.4	Downstream	The following are taken at an an equivalent depth of 8 feet below water surface. (**)
20b	0.3	Downstream	
30a	0.4	20°R	Center pump, Q = 732 cfs.
30b	0.4	15°R	
30c	0.5	Downstream	
30d	0.7	20°L	
30e	0.6	45°L	
30f	0.6	45°L	
30g	0.2		No definite direction.
40a	1.5	Downstream	
40b	1.4	Downstream	
40c	1.5	15°L	
40d	0.0	90°L	
40e	0.0		No definite direction.
40f	0.0		No definite direction.
50a	1.4	Downstream	
50b	1.5	Downstream	
50c	0.8	Downstream	
50d	0.0		No definite direction.
50e	0.0		No definite direction.
50f	0.0		No definite direction.
58a	1.3	5°L	
58b	0.8	Downstream	
58c	1.0	5°R	
60a	1.4	30°R	
60b	1.2	10°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

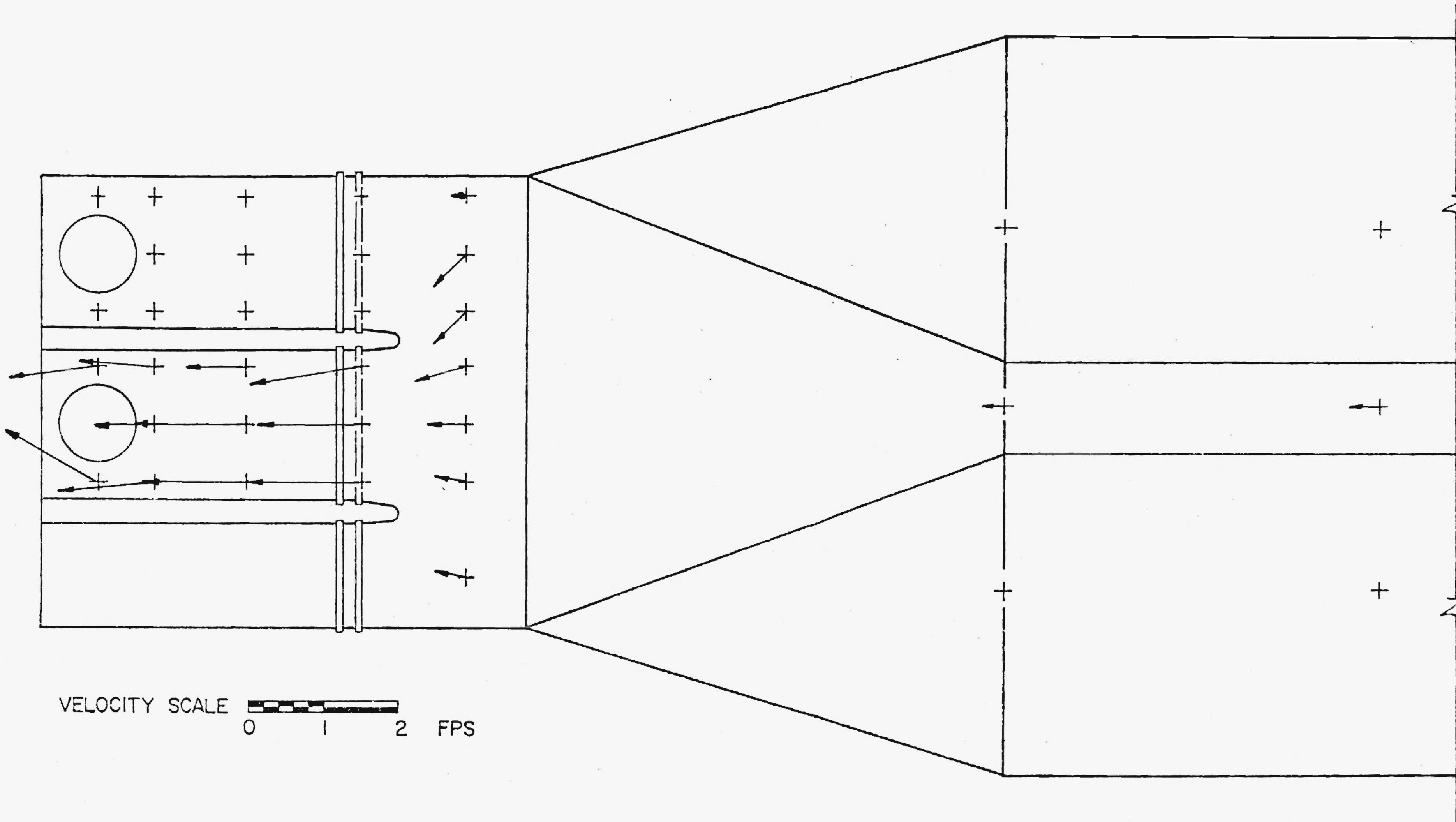


FIGURE 29. APPROACH VELOCITIES AT ELEVATION 206, PUMP FLOW RATE 732 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 19. Velocities in Approach Channel
in 1:8 Scale Model
Center Bay Pump Only
At 135% Design Flow

Model Station(*)	Prototype Velocities ft/sec	Direction	Comments
30a	0.5	50°R	The following are taken at an equivalent depth of 16 feet below water surface. (**)
30b	0.3	20°R	
30c	0.6	Downstream	
30d	0.7	30°L	
30e	0.6	50°L	Center pump, Q = 732 cfs.
30f	0.6	45°L	
30g	0.0	45°L	
40a	1.6	Downstream	
40b	1.5	Downstream	
40c	1.6	15°L	
40d	0.0		No definite direction.
40e	0.0		No definite direction.
40f	0.0		No definite direction.
50a	1.6	Downstream	
50b	1.7	Downstream	
50c	0.8	Downstream	
50d	0.0		No definite direction.
50e	0.0		No definite direction.
50f	0.0		No definite direction.
58a	1.7	15°R	
58b	1.5	45°R	
58c	1.6	30°L	
60a	1.9	45°R	
60b	1.9	45°L	

(*) See definition sketch.
(**) Water surface elevation at Pump Intake Station = 214 feet, floor elevation = 190 feet.

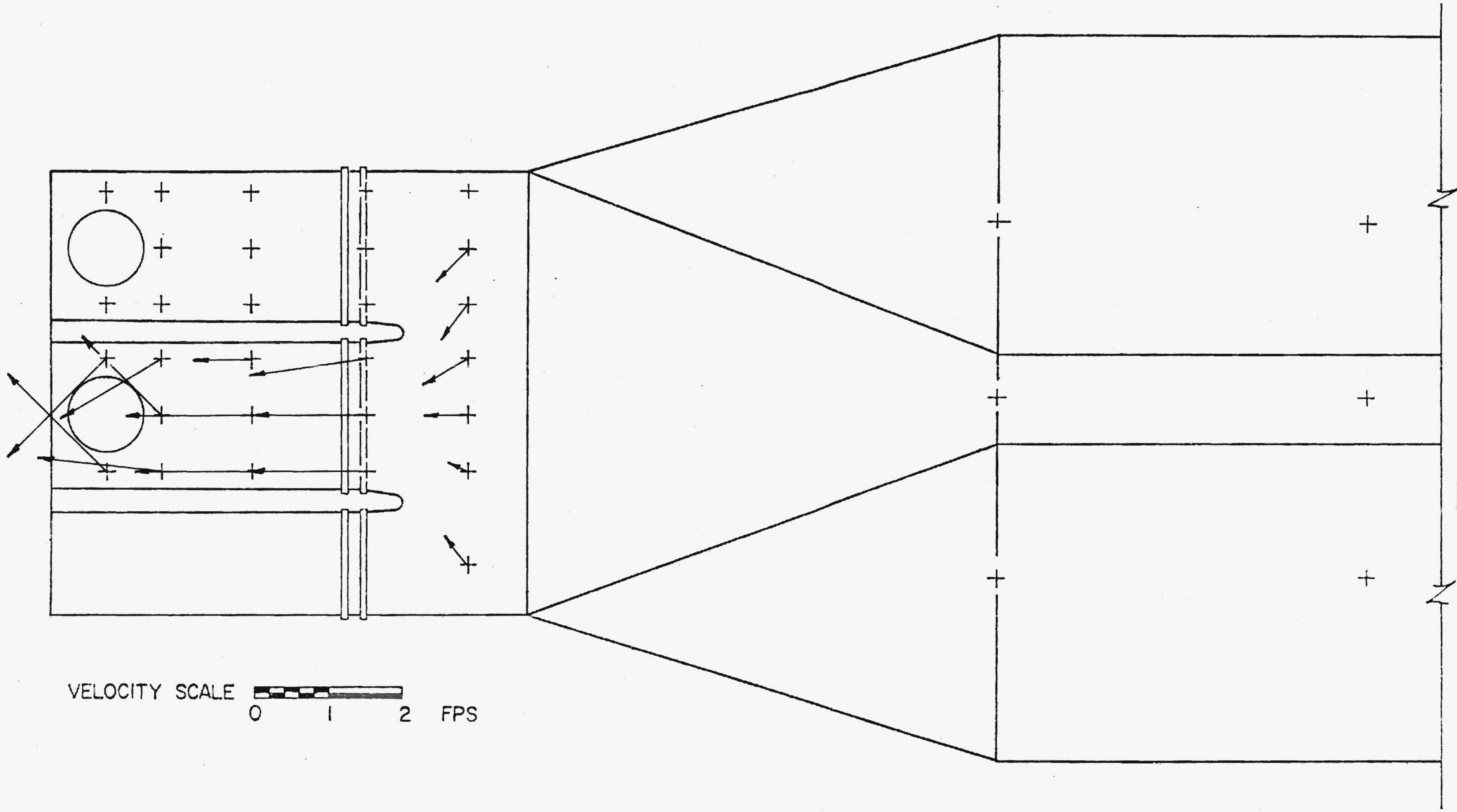


FIGURE 30. APPROACH VELOCITIES AT ELEVATION 198, PUMP FLOW RATE 732 CFS IN CENTER PUMP ONLY

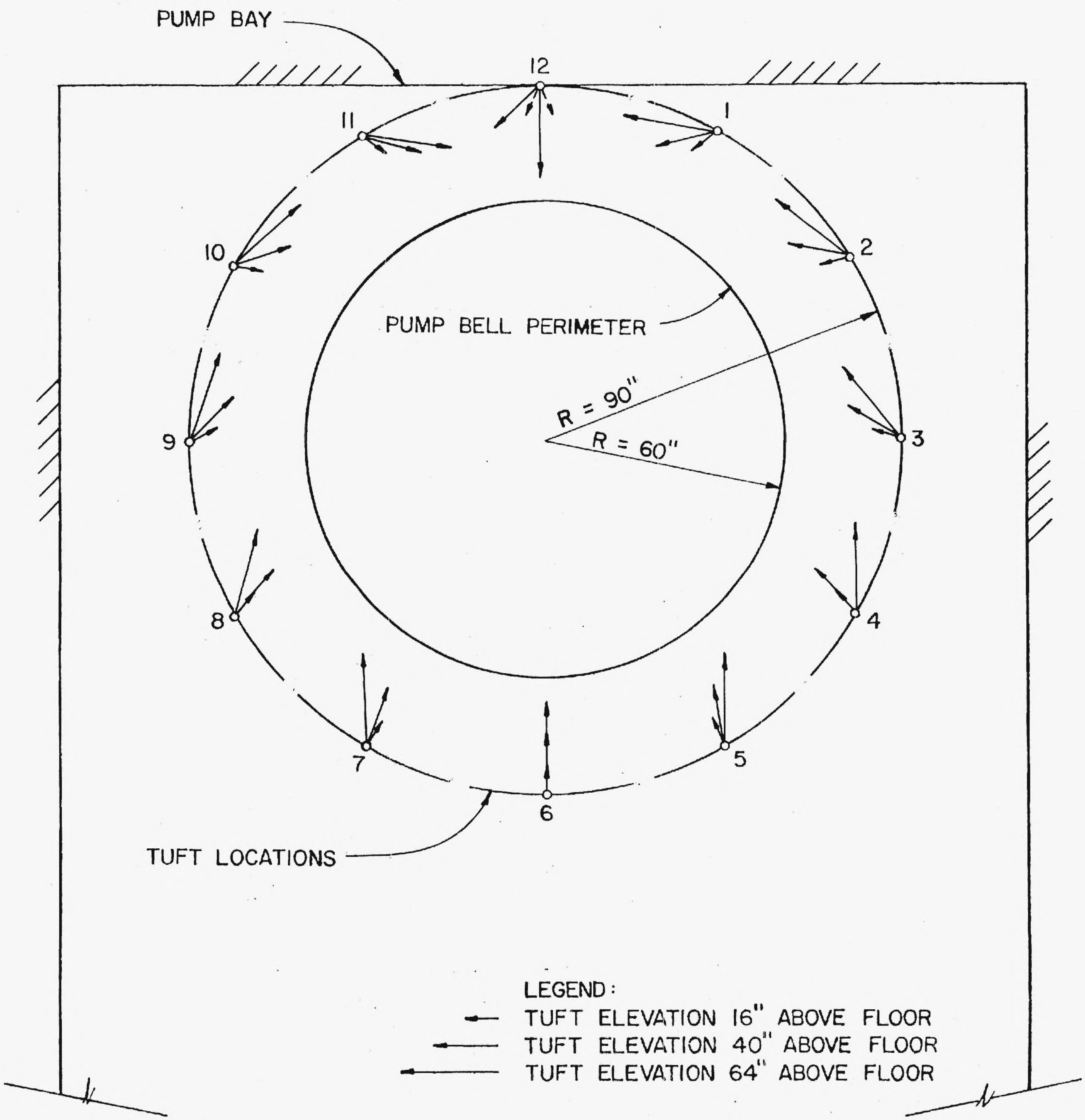


FIGURE 31. FLOW DIRECTIONS AT NORTH SUCTION BELL, PUMP FLOW RATE 542 CFS IN NORTH AND CENTER PUMPS

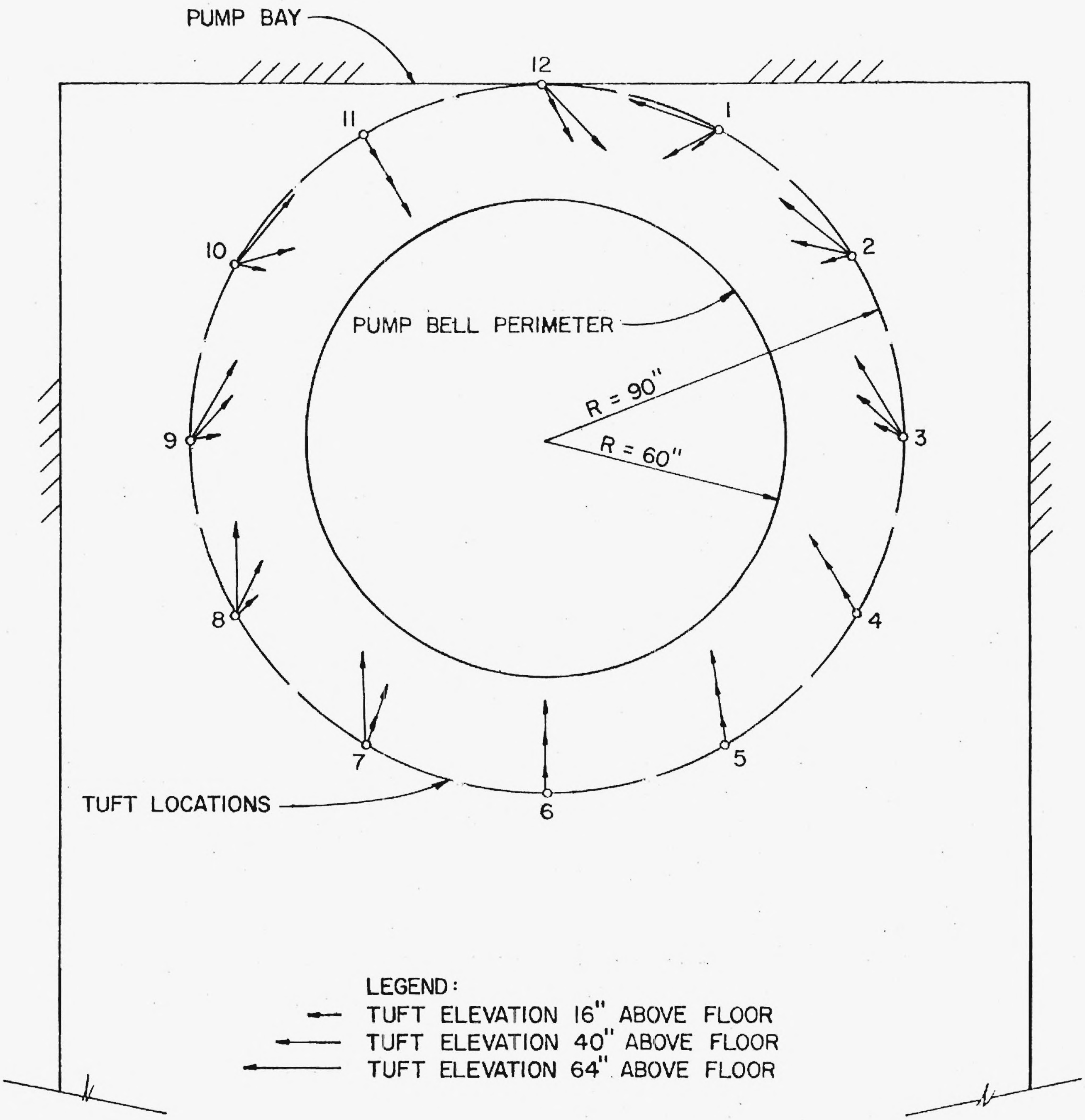
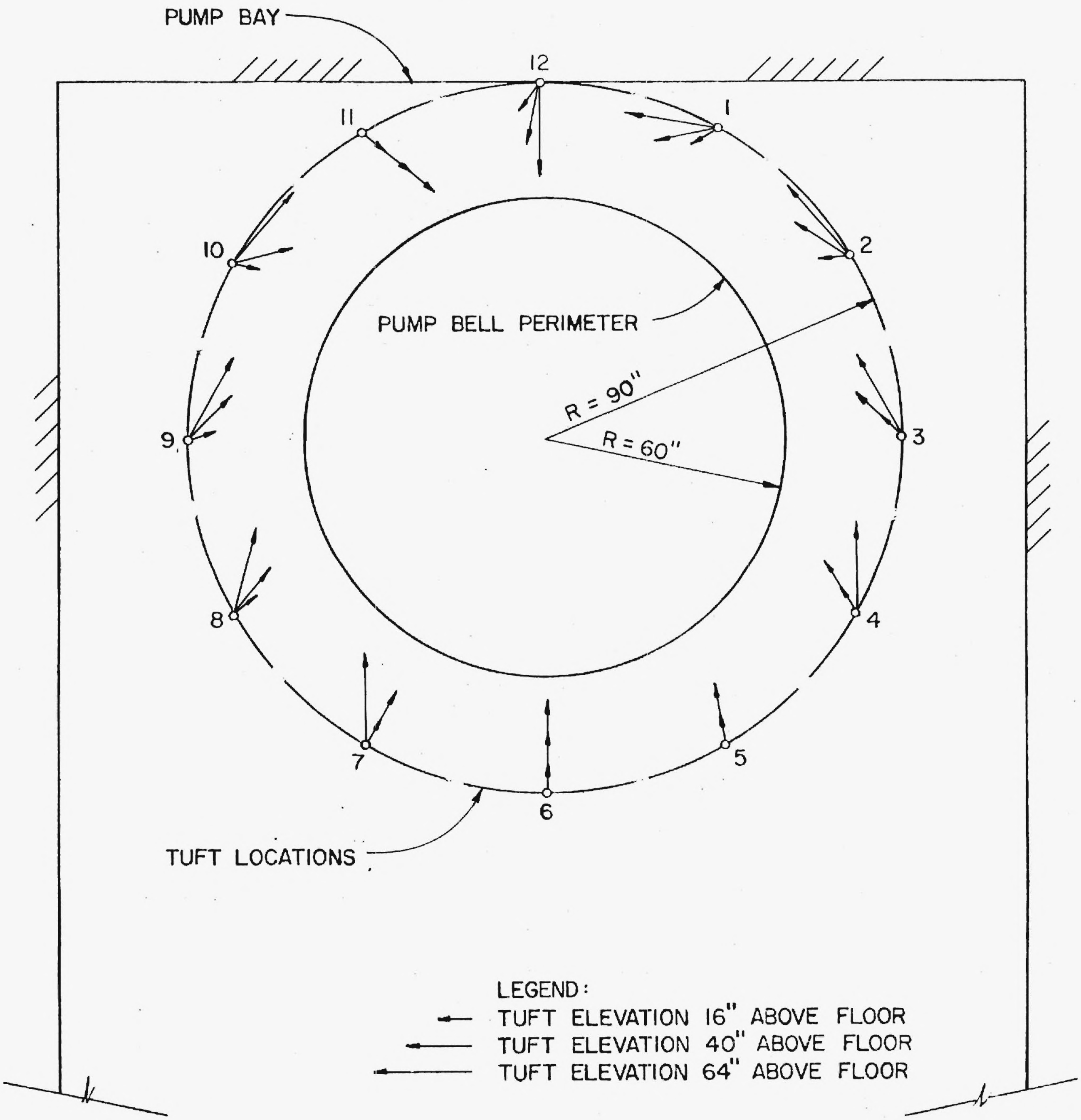


FIGURE 32. FLOW DIRECTIONS AT CENTER SUCTION BELL, PUMP FLOW RATE 542 CFS IN NORTH AND CENTER PUMPS



GURE 33. FLOW DIRECTIONS AT NORTH SUCTION BELL, PUMP FLOW RATE 542 CFS IN NORTH PUMP ONLY

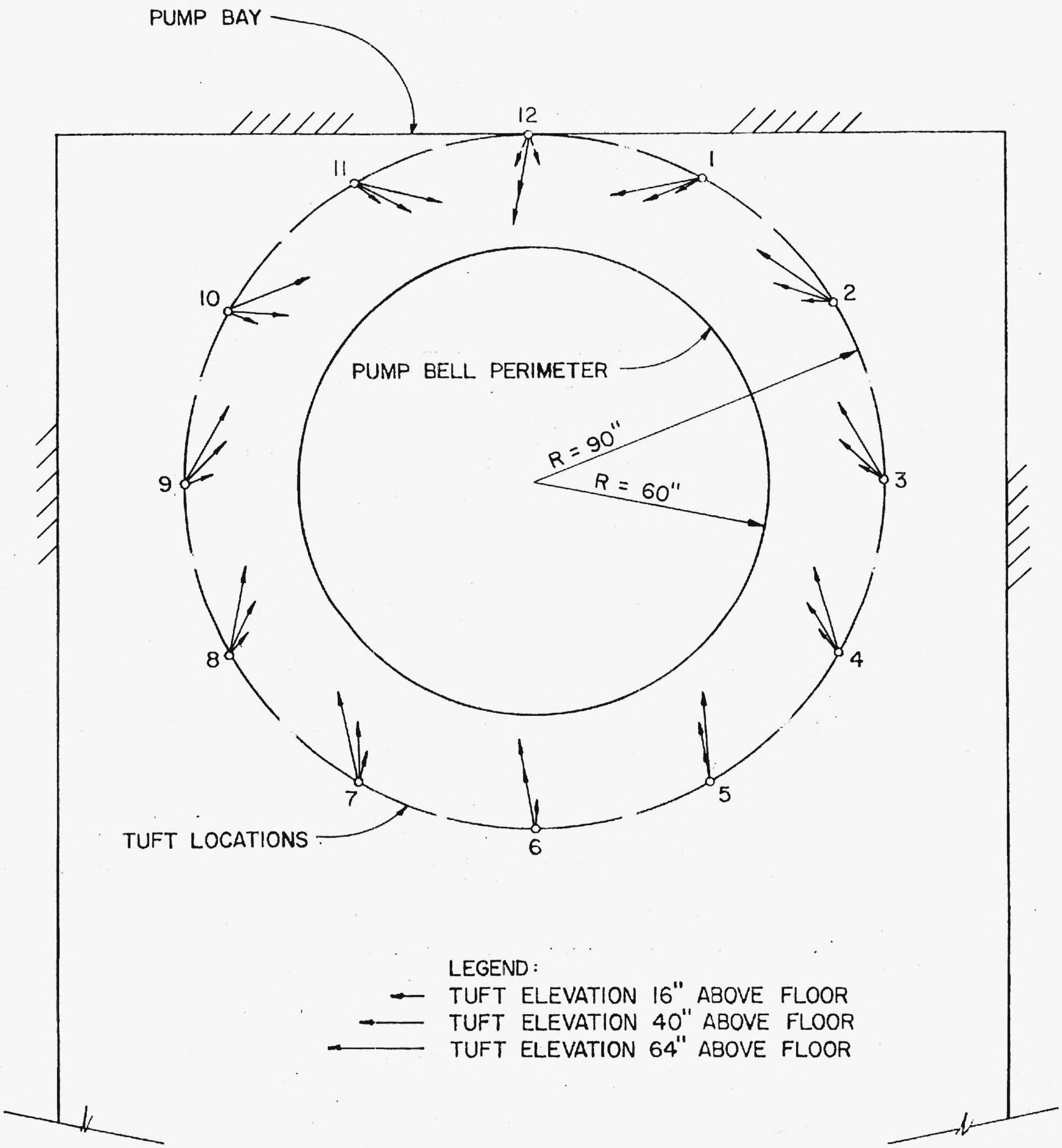


FIGURE 34. FLOW DIRECTIONS AT CENTER SUCTION BELL, PUMP FLOW RATE 542 CFS IN CENTER PUMP ONLY

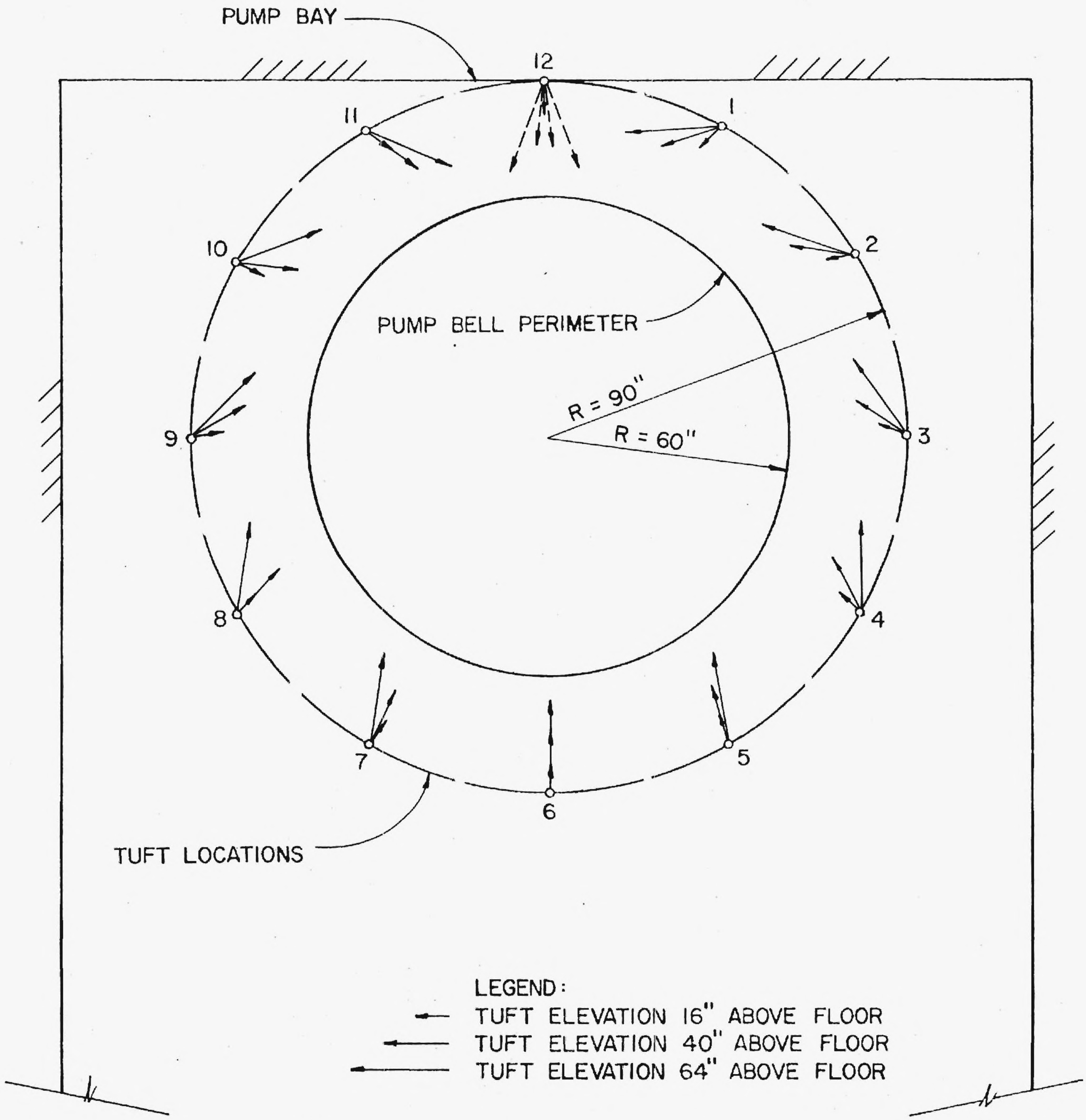


FIGURE 35. FLOW DIRECTIONS AT NORTH SUCTION BELL, PUMP FLOW RATE 677 CFS IN NORTH AND CENTER PUMPS

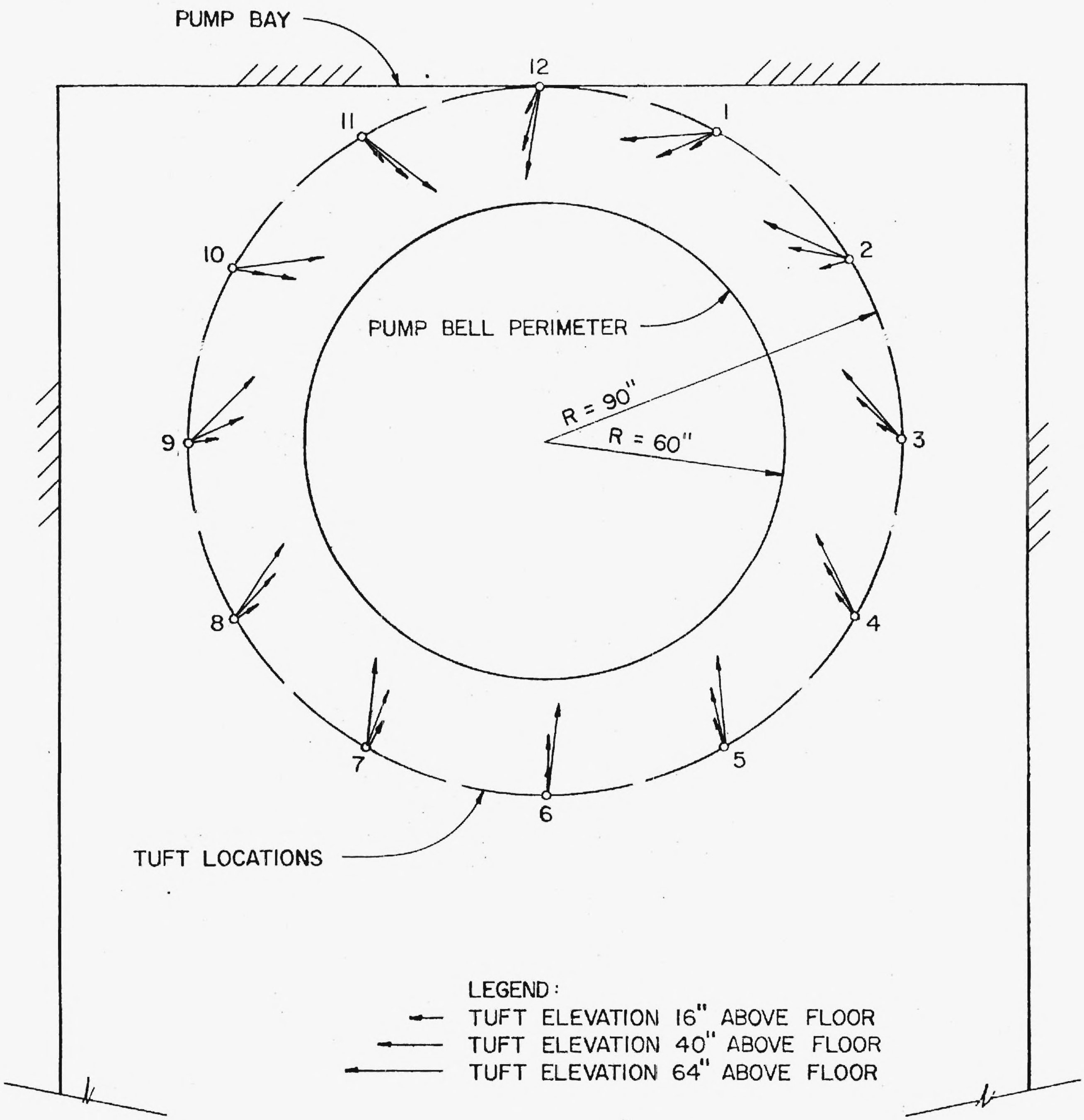


FIGURE 36. FLOW DIRECTIONS AT CENTER SUCTION BELL, PUMP FLOW RATE 677 CFS IN NORTH AND CENTER PUMPS

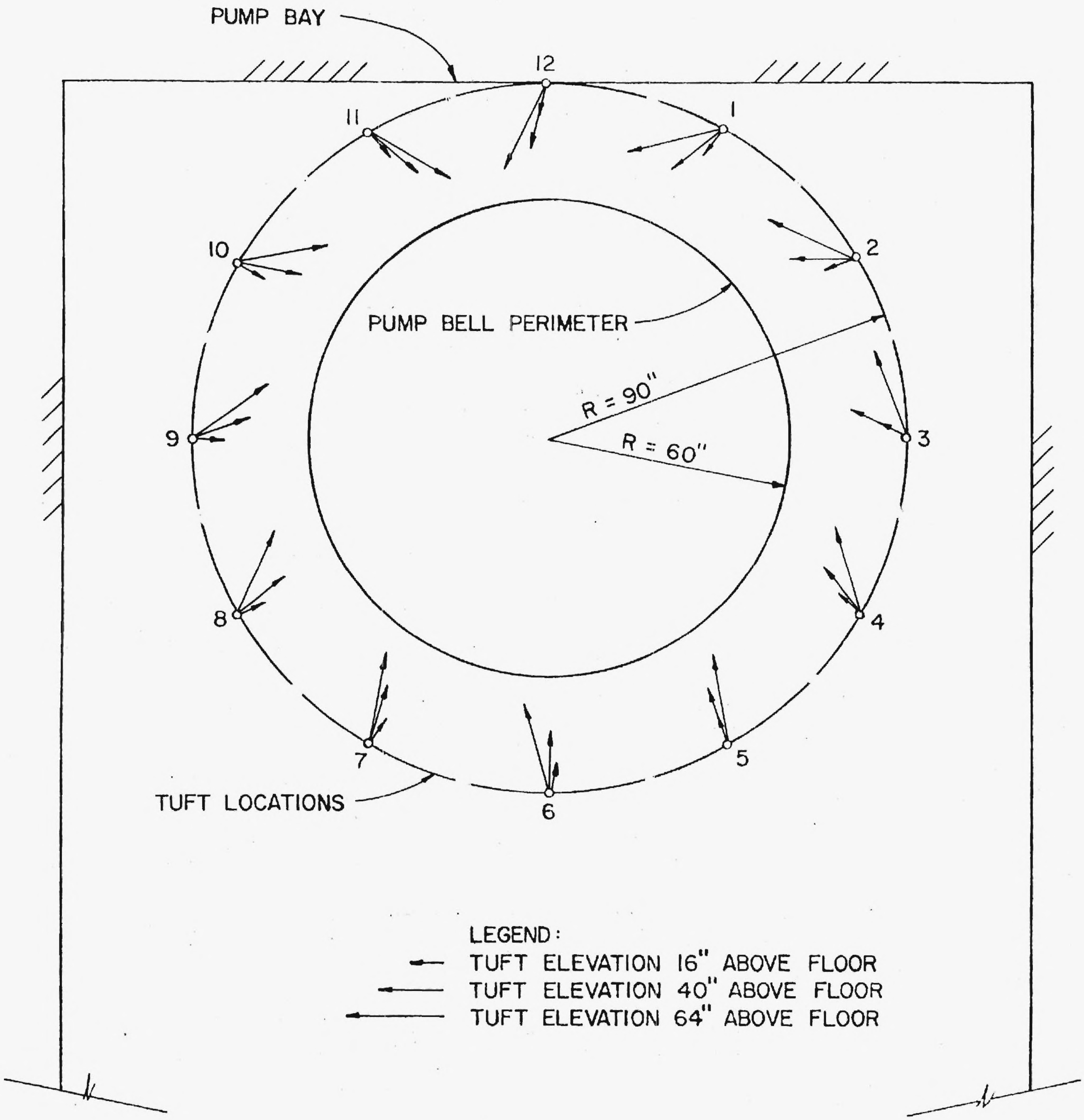


FIGURE 37. FLOW DIRECTIONS AT NORTH SUCTION BELL, PUMP FLOW RATE 677 CFS IN NORTH PUMP ONLY

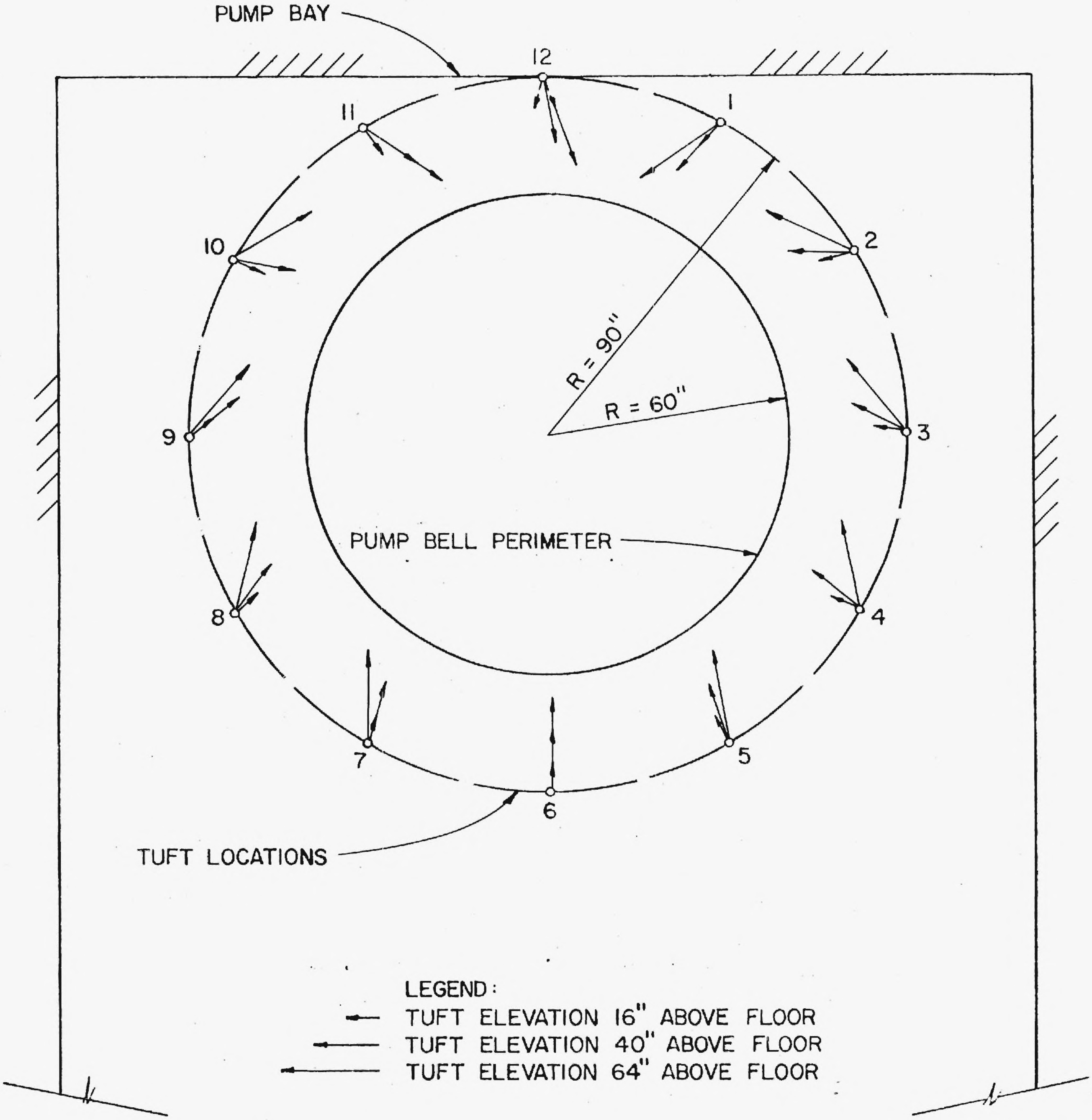


FIGURE 38. FLOW DIRECTIONS AT CENTER SUCTION BELL, PUMP FLOW RATE 677 CFS IN CENTER PUMP ONLY

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 20. Vortimeter Study in 1:8 Scale Model Pump Suction Lines

Run	North Pump* Rev/60 sec		Center Pump* Rev/60 sec		Comments
	(+)	(-)	(+)	(-)	
1	+15	- 0	+ 3	- 0	Both large circulating water pumps operating at design flow, Q = 542 cfs.
2	+11	- 0	+ 6	- 0	
3	+ 8	- 0	+10	- 0	Turbine cooling water pump operating.
4	+ 7	- 0	+ 8	- 0	
5	+10	- 0	+11	- 0	Water surface elevation = 214 feet, floor elevation = 190 feet.
6	+ 8	- 0	+ 3	- 0	
7	+ 6	- 0	+ 7	- 0	Vortimeter results represent ten runs each with vortimeters Nos. 1 and 2 in the North and Center pumps, respectively.
8	+ 7	- 0	+10	- 0	
9	+ 1	- 0	+ 5	- 0	
10	+12	- 0	+ 6	- 0	
11	+ 5	- 0	+ 7	- 0	
12	+ 4	- 0	+ 7	- 0	
13	+11	- 0	+ 4	- 0	
14	+ 1	- 0	+ 9	- 0	
15	+ 5	- 0	+11	- 0	
16	+18	- 0	+ 7	- 0	
17	+ 3	- 0	+10	- 0	
18	+ 7	- 0	+ 7	- 0	
19	+ 4	- 0	+ 7	- 0	
20	+ 8	- 0	+ 9	- 0	
Avg.	+ 8	- 0	+ 7	- 0	

*Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 21. Vortimeter Study in 1:8 Scale Model Pump Suction Lines

Run	North Pump* Rev/60 sec		Center Pump* Rev/60 sec		Comments
	(+)	(-)	(+)	(-)	
1	+15	- 0	+ 3	- 0	Both large circulating water pumps at design flow, Q = 542 cfs.
2	+11	- 0	+ 6	- 0	
3	+ 8	- 0	+ 6	- 0	Turbing cooling water pump operating.
4	+ 7	- 0	+ 8	- 0	
5	+10	- 0	+11	- 0	Water surface elevation = 214 feet, floor elevation = 190 feet.
6	+ 8	- 0	+ 3	- 0	Vortimeter results represent ten runs each with vortimeters Nos. 1 and 2 in the North and Center pumps, respectively.
7	+ 6	- 0	+ 7	- 0	
8	+ 7	- 0	+10	- 0	
9	+ 1	- 0	+ 5	- 0	
10	+12	- 0	+ 6	- 0	
11	+ 5	- 0	+ 7	- 0	
12	+ 4	- 0	+ 7	- 0	
13	+11	- 0	+ 4	- 0	
14	+ 1	- 0	+ 9	- 0	
15	+ 5	- 0	+11	- 0	
16	+18	- 0	+ 7	- 0	
17	+ 3	- 0	+10	- 0	
18	+ 7	- 0	+ 7	- 0	
19	+ 4	- 0	+ 7	- 0	
20	+ 8	- 0	+ 9	- 0	
Avg.	+ 8	- 0	+ 7	- 0	

* Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 22. Vortimeter Study in 1:8 Scale Model Pump Suction Lines

Run	North Pump* Rev/60 sec		Center Pump* Rev/60 sec		Comments
	(+)	(-)	(+)	(-)	
1	+ 5	- 0	+12	- 0	Both large circulating water pumps at 125% design flow, Q = 677 cfs.
2	+ 7	- 0	+13	- 0	
3	+ 5	- 0	+19	- 0	Turbine cooling water pump operating.
4	+ 9	- 0	+14	- 0	
5	+ 9	- 0	+ 7	- 0	Water surface elevation = 214 feet, floor elevation = 190 feet.
6	+ 0	- 4	+12	- 0	
7	+ 0	- 0	+18	- 0	Vortimeter results represent ten runs each with vortimeters Nos. 1 and 2 in the North and Center pumps, respectively.
8	+ 7	- 0	+21	- 0	
9	+17	- 0	+15	- 0	
10	+ 3	- 0	+13	- 0	
11	+ 7	- 0	+17	- 0	
12	+ 4	- 0	+16	- 0	
13	+ 9	- 0	+20	- 0	
14	+15	- 0	+17	- 0	
15	+ 0	- 1	+ 9	- 0	
16	+ 6	- 0	+ 7	- 0	
17	+ 3	- 2	+14	- 0	
18	+ 7	- 0	+10	- 0	
19	+ 5	- 0	+ 7	- 0	
20	+ 6	- 0	+16	- 0	
Avg.	+ 8	- 0	+14	- 0	

* Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table 23. Vortimeter Study in 1:8 Scale Model
Pump Suction Lines

Run	North Pump * Rev/60 sec		Center Pump * Rev/60 sec		Comments
	(+)	(-)	(+)	(-)	
1	+15	- 0	+ 0	- 4	Each large circulating water pump seperate at 125% design flow Q = 677 cfs.
2	+16	- 0	+ 0	-11	
3	+13	- 0	+ 0	- 8	
4	+ 7	- 0	+ 0	- 8	Turbine cooling water pump operating.
5	+10	- 0	+ 0	-12	
6	+16	- 0	+ 0	- 4	Water surface elevation = 214 feet, floor elevation = 190 feet.
7	+13	- 0	+ 0	- 2	
8	+15	- 0	+ 0	-15	Vortimeter results represent ten runs each with vortimeters Nos. 1 and 2 in the North and Center pumps, respectively.
9	+13	- 0	+ 1	- 4	
10	+13	- 0	+ 0	- 5	
11	+12	- 0	+ 0	- 5	
12	+23	- 0	+ 0	- 4	
13	+15	- 0	+ 0	- 7	
14	+19	- 0	+ 0	- 7	
15	+12	- 0	+ 0	- 7	
16	+18	- 0	+ 0	- 8	
17	+17	- 0	+ 0	- 5	
18	+24	- 0	+ 0	- 8	
19	+14	- 0	+ 0	-12	
20	+17	- 0	+ 0	- 7	
Avg.	+15	- 0	+ 0	- 7	

*Positive revolutions are clockwise looking in the direction of flow.

VI. Conclusions and Recommendations

Hydraulic tests were conducted on a 1:8 scale model of the Plant Vogtle Circulating Pump Intake Structure. The tests were carried out at the request of the Southern Company Services, Inc., to satisfy performance criteria usually specified by designers and by pump manufacturers. These test criteria pertain to hydraulic flow patterns in structures or structural passages prior to the pump suction bells. Rarely are the exact pump suction bell configurations modeled, and the actual pumps have never been modeled or tested by the purchasers of equipment.

A summary of model test criteria as well as the model's performance in terms of these criteria is presented in Table 24. It is presumed that these criteria apply to design flow conditions. An analysis of the test results indicated that the flow conditions in the Plant Vogtle Pump Intake Structure are generally satisfactory. The test results are reviewed below.

Some of the model test results were inevitably influenced by extraneous flow patterns which existed only in the model. Specifically, some vortex motion within the pump intake structure model was discovered to be due to large-scale turbulence generated in the model head bay and insufficiently dissipated in the approach channel. After steps were taken to dissipate much of this large-scale turbulence in the head bay, the free surface vortices disappeared in the intake structure, even under the conditions of elevated flow rates and minimum water surface elevation.

Table 24. Test Criteria and Test Results

Item	1. Bechtel	2. Southern Services	3. Ingersoll-Rand	Georgia Tech Results
Vortex	No surface or subsurface	No air entrained	No free surface	Satisfactory
Flow separation at pump throat	Not allowed	*	*	Not investigated
Pre-rotation at pump throat	About 3-5 rpm	Less than 10 rpm	20 rpm	Satisfactory for 2. and 3.
Velocity deviation at pump throat	About 3 percent	Less than 5 percent	*	See conclusions
Flow angularities	Less than 10-12° from vertical axis	Less than 10° from ideal radial flow	Less than 10° from ideal radial flow	See conclusions

*No criterion specified

Actually, the modified turbulence observed in the rectangular model head bay was still fairly intense and not at all typical of the more tranquil flow patterns occuring in the large circular basin underneath the prototype cooling towers. Thus, it is concluded that the model test results, although not ideal themselves, do indicate satisfactory flow patterns in the intake structure. Only infrequent, intermittent and weak rotational flows were sometimes observed. However, these flow patterns never persisted long enough or were strong enough to affect air-entrainment into the circulating water pumps.

The pump intake structure consists of three bays as shown in Figure 3. The two circulating water pump bays have each a width of twenty feet, or twice the pump suction bell diameter, D. The centerlines of the circulating water pumps are located equidistant from the side walls and 0.75 D from the end walls. The third bay houses two turbine cooling water pumps and is fourteen feet wide. Since the entire intake structure is centered on the trapezoidal return channel, see Figures 1 and 2, the circulating water pumps, as a pair, are located asymmetrically relative to the axis of the return channel. This asymmetry is even more pronounced when the North pump is operated by itself.

The velocity surveys in the return channel and in the pump bays were made with a midget current meter for determinations of the magnitude of the velocity vectors, and with dye streaks for the determination of flow directions. In the test program it was not possible to always coincide the meter locations with the points of dye releases, both horizontally and vertically. This was likely to be more critical within the pump bays near the pumps in reaches of rapidly accelerated flows. Yet, within the margin of experimental error, the velocity vectors appeared to be reasonably symmetrical and steady.

A close-up velocity survey was made around each suction bell and for various flow conditions by using tufts mounted on wire poles. The tufts were situated in a circular pattern some 0.25 D outside the rim of the suction bells. As indicated on the flow direction diagrams, the three tufts mounted on one pole at three different elevations showed also different radial flow orientations. The lowest tufts were always in the most ideal (radial) direction and the higher tufts indicated the presence of greater forward momentum in the flow alongside the pump barrels. Purely radial inflows would only be found in the absence of forward momentum and would require very large pump bays. Within practical limits and within the finite size of the Plant Vogtle Intake Structure, the importance of the prevailing flow patterns lie in their essential symmetries.

Completely symmetrical inflow patterns into the circulating water pumps would preclude prerotation of the flows in the suction lines. The amount of flow prerotation has a direct effect on pump efficiency. Moreover, ideal flow patterns do not frequently exist and some prerotation is acceptable as a rule. Ingersoll-

Rand indicated an upper acceptable limit of twenty revolutions per minute.

In the model tests some prerotation was observed and re-dorded. Since the observations were made in an 8-inch diameter suction pipe, the observed prerotation may have been more severe than that which would have resulted in a larger diameter pipe. In the interpretation of the model test results it is concluded that the observed revolutions were probably larger than the actual prerotation existing at the pump suction bells. The test results were, therefore, indicative of satisfactory flow conditions in the Plant Vogtle Intake Structure.

As was indicated above, some of the model test results were influenced by extraneous flow patterns which existed only in the model. Although considerable improvements were made in the flow conditions in the model head bay, further improvements in the model approach flow conditions are possible. However, the need for quick results and the lack of information on actual flow patterns in the prototype channel counselled against futher flow modification studies in the present model.

The model test results suggested also two alternate changes in the prototype system geometry which would improve flow patterns in the pump intake structure. One change would be a lateral shift of the present pump intake structure, which would align the center-line of the two circulating water pumps, as a pair, with the axis of the trapezoidal return channel. The alternate change would be the elimination of the bay containing the two turbine cooling water pumps. As a result, the same lateral shift of the intake structure as described above would place the circulating pumps symmetrically into the system, and one turbine cooling water pump would be placed in front of each of the two circulating water pumps. No verification tests have been conducted on these possible system modifications.

E-20-619

ADENDUM TO FINAL REPORT

PROJECT NO. E-20-619

VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

By

Paul G. Mayer

Prepared for

SOUTHERN COMPANY SERVICES
BIRMINGHAM, ALABAMA

December, 1978

GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL ENGINEERING
ATLANTA, GEORGIA 30332

1978

VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES

Addendum to Final Report

by

Paul G. Mayer

Project No. E-20-619
Southern Company Services
Birmingham, Alabama

December 1978

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VOGTLE NUCLEAR PLANT HYDRAULIC MODEL STUDIES
ADDENDUM TO FINAL REPORT, DECEMBER 1978

I. Introduction

This report summarizes all studies and tests on the Vogtle Nuclear Plant Hydraulic Models which were carried out subsequent to those studies and tests previously reported in January 1978.

The Alvin W. Vogtle Nuclear Power Plant is a proposed electric power generating station of the Georgia Power Company. The location of Plant Vogtle is several miles below the City of Augusta, Georgia in the proximity of the Savannah River. The design of Plant Vogtle has been carried out by the Bechtel Corporation of Los Angeles, California under contract to the Southern Company Services, Incorporated, of Birmingham, Alabama, and the Georgia Power Company with headquarters in Atlanta, Georgia.

The circulating cooling water system of Plant Vogtle is an essential component of that facility. Its design, design verification, and design modification are the subject of careful study and review. In this context, Southern Company Services contracted with Georgia Institute of Technology, School of Civil Engineering, to build and test a hydraulic model of the circulating water system intake structure. The liaison with Southern Company Services was carried out through Mr. G. B. Dougherty. The principal investigator was Dr. Paul G. Mayer, Regents' Professor of Civil Engineering, Georgia Institute of Technology.

II. Purpose and Scope

The previous studies had been made with a three-bay intake structure and a trapezoidal approach channel, one pump bay was used for each of the two cocling water circulating pumps, and the third bay was used to accommodate two turbine cooling water pumps. As a result of tests on the three-bay model, it was suggested that a two-bay model be investigated which would place the circulating water pumps symmetrically into the system with one turbine cooling water pump placed in front of each of the two circulating water pumps.

Hydraulic model tests were carried out on 1:8 and 1:40 scale models with a two-bay intake structure. The two-bay models were tested with basically two different cross sections of approach channel. The model with a trapezoidal approach channel was designated as VOGTLE II, and the model with a rectangular approach channel was designated as VOGTLE III. Each model was tested to ascertain prevailing flow conditions and flow patterns and to establish specifically:

a. the flow patterns and velocity distribution in the approach channel,

b. the flow patterns and velocity distribution in the pump bays,

c. the flow patterns and velocity distribution in close proximity of the circulating water pump suction bells, and

d. the amount and direction of pre-rotation of the flow in the pump suction lines.

All test results were to be submitted for review and consultation as they became available, and a compendium of all test results were to be submitted as an Addendum to the Final Report.

III. The Hydraulic Models

In modeling the Plant Vogtle Pump Intake Structure, both geometrical and dynamical similitude requirements were considered. It was agreed that the dynamical similitude must be based on the Foude criterion and that the viscous effects and the surface tension effects could be neglected. The effects of the viscous forces on the general flow patterns in the model were minimal in view of the large Reynolds number flows which insured the presence of fully-turbulent conditions. The influence of viscousity and of surface tension on the formation of air-entraining vortices is not yet understood. However, since the air-entrainment is connected with free-surface vortices, the absence of such vortices in the model is usually accepted as a satisfactory test result.

The 1:8 scale undistorted models were built and tested. The corresponding velocity scale was 1:2.83, and the model discharges were based on a ratio of 1:181. For verification of the approach flow conditions, 1:40 scale models were also built and tested. The corresponding velocity scale was 1:6.32, and the model discharges were based on a ratio of 1:10,120.

The model VOGTLE II was characterized by a two-bay pump intake structure and by a trapezoidal approach channel.

The models were built to conform to design drawings provided by the Southern Company Services. A schematic plan view of the system is shown in Figure A1. In the proposed prototype, the cooling water is collected in a large circular basin underneath the cooling tower. The water is then discharged into a trapezoidal channel and returned into the pump intake structure. The trapezoidal channel has a 12-foot wide bottom and side slopes of one on two. A channel transition then conveys the flow into the rectangular pump intake structure.

Figure A2 shows a photograph of the 1:40 scale model VOGTLE II in the laboratory. The tower basin was modeled to receive a simulated distributed inflow by means of a series of perforated pipes. Figure A3 shows the tower basin in operation. The channel transition and pump intake structure of the 1:40 scale model are shown in Figure A4.

The extent of the 1:8 scale model is shown in Figure A5. The cooling tower and a portion of the return channel were simulated by a head tank approximately 12 feet wide, 8 feet long, and 4 feet deep. Some 14 feet of trapezoidal channel in the model represented about 112 feet of the prototype channel, or approximately 65 percent. The channel transition was modeled in its entirety as was the pump intake structure. A plan view of the intake structure model VOGTLE II is shown in Figure A6, and a longitudinal profile of the model is shown in Figure A7. Figure A8 shows an elevation view of the intake structure.

In the prototype VOGTLE II intake structure, there are two bays to house one circulating water pump each with a rated capacity of 242,000 gallons per minute, or about 542 cubic feet per second. One turbine cooling water pump, with a rated capacity of 14,000 gallons per minute, is placed in front of each circulating water pump.

In the model, the pumps were simulated by horizontal centrifugal pumps with appropriately shaped suction bells. An overall view of the VOGTLE II model during construction is shown in Figure A9. The pump suction lines and the return lines were made of PVC piping. At each end of the return lines, sections of 6-inch diameter spiral-weld pipe contained calibrated elbow meters and flow control valves. The pump suction bells were made of cast acrylic to conform to the pump bell specifications. Figure A10 shows the channel transition during construction.

During operation of the model, local velocities were measured with a calibrated midget current meter. The flow directions were traced by means of dye streaks. Flow patterns around the pump bells were observed by means of dye streaks and also by means of colored tufts mounted on wire poles. Close visual inspection was accommodated by plexiglass windows in the pump bays. A metal shroud was placed over the PVC suction pipe to correspond more closely to the prototype dimensions of the circulating water pumps. A close-up view of the pump suction bell and the colored tufts as seen through a plexiglass window is shown in Figure A11.

For the study of pre-rotation of flow in the suction pipes, vortimeters were fabricated and installed. These vortimeters consisted of four-bladed no-pitch propellers mounted inside the riser pipes of the suction lines. For observation of the prevailing prerotating flow patterns, plexiglass windows were inserted into the PVC suction pipes. Figure A12 shows an installed vortimeter. A photograph of a cast pump suction bell is shown in Figure A13.

The VOGTLE III model was characteristically different in that it had a rectangular approach channel. The width of the approach channel coincided with the width of the pump intake structure, namely 43 feet. The longitudinal vertical profile of VOGTLE III is shown in Figure A16. Figure A17 shows the 1:40 scale VOGTLE III model in operation. The 1:40 scale model of VOGTLE III is shown in Figure A18. A view into the intake structure shows the pump suction lines and the pump suction bells, Figure A19.

A special effort was necessary in the 1:8 scale VOGTLE models to reproduce approach channel flow patterns. This effort was directed toward the elimination of extraneous turbulence and eddying in the model head box. For this purpose, rolls of wire-mesh fencing were stacked around the return pipe exits and various baffles were arranged to straighten out the flow so as to conform to the flow patterns observed in the comprehensive 1:40 scale models. Figure A20 shows the stilling devices at the entrance to the VOGTLE III 1:8 scale model.

IV. Test Procedures

Previous testing on VOGTLE models had indicated a strong dependency of the flow patterns in the pump intake structure on flow conditions prevailing in the head box. In order to assess the effective return flow-patterns, the 1:40 scale models of VOGTLE II and VOGTLE III were observed and velocity distributions were measured. Figure A14 shows the VOGTLE II model with current meter readings in process. These velocity measurements were then used to "tune" the larger 1:8 scale model.

In the 1:8 scale VOGTLE models, the dissipation of large-scale turbulence created in the head box by the concentrated return flow jets was essential. Rolls of wire-mesh fencing together with perforated baffle plates were inserted into the head box to provide adequate stilling. Subsequent measurements of velocity distributions in the return channel showed near-uniform flow. More importantly, the stilling of the flow in the head box also eliminated essentially all surface vortices observed during preliminary tests. Systematic test series were then conducted to establish:

a. velocity distributions in the return channels,

b. flow patterns in the proximity of the circulating water pump bells, and

d. pre-rotation in the suction lines.

<u>Approach Channel Velocity Distributions</u>: Velocity measurements were made in the trapezoidal return channel of VOGTLE II and in the rectangular channel of VOGTLE III at six stations, designated as A, B, C, D, E, and F. Figure A15 shows the location of the measuring stations in the 1:8 scale hydraulic model. As indicated in Figure A15, the first measuring station (Station F) was located some 10 pumpbell diameters, or 100 feet, upstream from the intake structure and at the end of the trapezoidal return channel. Subsequent measuring stations were located in the channel transition and in the intake structure and were

designated as Stations A, B, C, D, and E. Within the intake structure, velocity measurements were made at 2 feet, 13 feet, and 24 feet below the water surface at all locations (elevations 212, 201, 190 feet). The water surface elevation was maintained at 214 feet, and the pump intake structure model had its floor at elevation 188 feet.

The circulating water pumps were designated as South Pump and North Pump to reflect their locations within the intake structure. One turbine cooling water pump <u>only</u> was operated during all test sequences. Velocity measurements were made for three different pump operating modes. The pump operating modes are shown in Table A1.

Table A1. Pump Operating Modes

Mode	North	South	Comments
1.	600	600	Design flow, Q = 542 cfs.
2.	600	0	600 cfs = 110% Design flow.
3.	0	600	

<u>Pump Bell Flow Patterns</u>: For the purpose of documentation of the flow pattern near the pump suction bells, tufted brass poles were located in 12 positions at a radial distance of 0.75D or 90 inches (prototype) from the pump suction bell center line. The tufts were mounted at 16 inches, 40 inches and 60 inches above the floor of the intake structure. The results gave the direction of the local velocities in their horizontal projections. Again, these observations were recorded for the three pump operation modes listed previously in Table A1.

<u>Pre-rotation in Suction Lines</u>: In each circulating pump suction line a no-pitch propeller (vortimeter) was installed immediately above the pump suction bell. Transparent sections of plexiglass were inserted into the suction lines to allow for observation of pre-rotation. For each of the three pumping modes, several sets of observations were recorded to obtain valid results.

V. Test Results

All test results represent repeated test measurement sequences. The results are listed in tabular form and are presented as graphs when appropriate. Generally, all test sequences were carried out for the three pumping modes listed in Table A1 and results are reported sequentially for velocity distributions in the return channel, pump bell flow patterns, and pre-rotation studies, both for VOGTLE II and VOGTLE III.

VOGTLE II--Approach Channel Velocity Distributions: In the VOGTLE II 1:40 scale model, flow patterns were studied by means of dye traces, and velocities were estimated by observing the time elapsed during dye transport between measuring stations. In the 1:40 scale model, the velocities were symmetrically distributed, and this information was then used to obtain equivalent velocity distributions in the 1:8 scale model of VOGTLE II. For comparison studies, Table A2 lists the comparable measuring stations for the two models. Greater accuracy was obtained in the 1:8 scale model.

Table A2. Comparable Measuring Stations in Approach Channels

1:40 Scale	1:8 Scale
60	D
50	E
40	F
34	G

For the approach channels, corresponding velocities with both pumps in operation are listed in Table A3 for an equivalent depth of two feet below the water surface, or an elevation of 212 feet, in Table A4 for mid-depth, and in Table A5 for an equivalent depth of two feet above the channel floor.

Comparable velocities in the approach channels with the North Pump only in operation are listed in Table A6 for elevation 212 feet, in Table A7 for mid-depth elevations, and in Table A8 for elevations two feet above the channel floor. With the South Pump only in operation, Table A9 lists the comparable velocities for elevation 212, Table A10 lists comparable velocities for mid-depths, and Table A11 lists comparable velocities for elevations two feet above the channel floor.

In order to obtain these comparable velocity distributions in the 1:40 and 1:8 scale models, considerable care was exercised in the 1:8 scale model to dissipate extraneous turbulence and eddying in the head bay. For this purpose, rolls of chain-link fencing were stacked around the return pipes and baffles were installed to straighten out the flow entering the fore-shortened approach channel. Figure A20 shows some of the baffles at the entrance to the 1:8 scale model approach channel.

Velocity measurements were made with a calibrated midget current meter. The direction of flow was determined by observation of dye streaks. Subsequent tables summarize the velocity measurements in the approach channel. The values in the tables correspond to prototype velocities. The measuring stations correspond to locations indicated on the definition sketch in Figure A15. The direction and magnitudes of the velocity vectors are presented in graphs.

The results of the comparison studies are presented in Tables A3 through A11. The velocity measurements in the 1:40 scale model resulted mainly from time-distance observations of dye traces and are less accurate than the current meter measurements in the 1:8 scale model. Some current meter measurements were also attempted in the 1:40 scale model. The tables summarize comparable velocity readings in the respective approach channels. Experiments were conducted for operational modes with both circulating water pumps in operation, with the North Pump only in operation, and with the South Pump only in operation.

After the "tuning" of the 1:8 scale was judged adequate, comprehensive velocity surveys were made in the 1:8 scale

VOGTLE II model. The results are presented in tables and in vector diagrams. The magnitudes of the velocities were obtained by means of current meter measurements. The direction of the velocity vectors were obtained by means of dye streaks. Thus, Table A12 and Figure A21 show the velocity distribution in the VOGTLE II 1:8 scale model when both pumps were operated at an equivalent flow rate of 600 cfs. The velocity measurements were made at an equivalent depth of two feet below the water surface. Velocity measurements for the same flow rates and at mid-depth locations are summarized in Table A13 and in Figure A22; the velocities at a depth of two feet above the channel floor are given in Table A14 and in Figure A23.

For the condition of the North Pump <u>only</u> operated at a flow rate of 600 cfs, Table A15 and Figure A24 show the velocity distribution at an equivalent depth of two feet below the water surface, Table A16 and Figure A25 show the velocity distribution at mid-depth, and Table A17 and Figure A26 show the velocity distribution at a depth of two feet above the channel floor.

For the condition of the South Pump <u>only</u> operated at a flow rate of 600 cfs, Table A18 and Figure A27 show the velocity distribution at a depth of two feet below the water surface, Table A19 and Figure A28 show the velocities at mid-depth, and Table A20 and Figure A29 show the velocities at a depth of two feet above the channel floor.

The VOGTLE II model had its pump intake structure floor at elevation 188. The water surface elevation during test sequences was maintained at elevation 214. The test sequences were repeated for two conditions of the pump intake structure, namely, without the splitter wall and with the splitter wall installed. Identical results were obtained for the approach flow velocity distributions under the two conditions.

The operation of the turbine cooling water pumps had no significant effects on the velocity distributions. Experiments were conducted with the South turbine cooling water in operation and alternately with both circulating water pumps, the North Pump only, and the South Pump only in operation. These experiments resulted in no measurable differences in the velocity distributions. Similar comparison tests were run with the North turbine cooling water pump in operation and, again, no significant influence on the velocity distribution could be detected.

VOGTLE II--Pump Bell Flow Patterns: Twelve 1/16-inch diameter brass rods were inserted into the model floor around each suction bell. Each rod was occupying an hourly position, with the twelve o'clock position being at the rear wall of each pump bay. Colored tufts were mounted on each rod at three different elevations. These positions correspond to prototype distances of 16 inches, 40 inches, and 60 inches above the floor of the intake structure. The radius of the brass rod locations was 0.75D. For the 1:8 scale VOGTLE II and VOGTLE III models, an additional set of brass rods was inserted into the model floor at the pump bell diameter. One tuft was attached to each rod at about mid-depth between the floor and the pump bell elevation.

Observations were made from above the model as well as through the plexiglass windows located in the side walls of the intake structure. The results are presented in a number of vector diagrams. In the interpretation of the diagrams, it is important to recognize that only the horizontal directions of the velocity vectors are indicated. As shown in the legends given on each diagram, the magnitude of the vectors refer only to the elevation of the tufts above the floor of the intake structure.

Generally, the tufts were observed to be stationary indicating steady flow conditions. When the tufts wafted about, indicating unsteady flow conditions, the directional vectors are presented in a dashed format. During some of the experiments, a brass rod may have been dislodged or the tufts may have been pulled off. For those conditions, no velocity vectors are recorded.

Figures A30 and A31 represent flow directions at the pump suction bells in the North and South bays of the VOGTLE II model when both circulating water pumps were operated at about 600 cfs, or about 110% of design flow, and where there were no splitter walls installed in pump bays. Figure A32 represents the flow directions at the North Pump suction bell when the North Pump <u>only</u> was operated at 600 cfs and when no splitter wall was installed.

Preliminary tests had demonstrated that a vertical splitter wall at the back wall of each pump bay was effective in eliminating flow pre-rotation in the pump suction lines, especially when only one circulating water pump was in operation. The resulting approach flows showed definite asymmetries. In the laboratory models, the splitter wall corresponded to a prototype section of 4 inches by 28 inches extending from the normal operating water level down to the proximity of the pump bell elevation. For reasons of practicality, a thicker splitter wall may be preferable and would have the same effect of inhibiting flow pre-rotation.

Figures A34 through A41 represent flow direction at the pump suction bells when splitter walls were installed in the pump bays. The splitter walls were located between the pump barrels and the back wall of the pump bays. They were thin vertical members fastened orthogonally to the back walls and extended from the normal operating water level down to various elevations. The two sets of experimental results included in this report were for splitter walls that terminated at the pump bay floor and that terminated seven feet above the floor, or at elevations 188 and 195, respectively.

Thus, Figures A34 and A35 show flow directions at the suction bells of the North Pump and South Pump, respectively, when both pumps were operated at 600 cfs and when the splitter walls were extended to elevation 188. Figure A36 shows flow direction at the North suction bell when the North Pump only was operated at 600 cfs and when the splitter wall was extended down to elevation 188. Figure A37 shows the flow directions for similar conditions in the South Bay were the South Pump only was operated.

Experiments with splitter walls terminated at elevation 195 yielded the results shown in Figures A38 through A41. Thus, Figures A38 and A39 show flow directions at the suction bells of the North Pump and the South Pump, respectively, when both pumps were operated at 600 cfs. Figure A40 shows flow directions when the North Pump only was operated, and Figure A41 shows flow direction when the South Pump only was operated.

VOGTLE II--Pre-rotation in Suction Lines: The results of studies of flow pre-rotation are presented next. Pre-rotation was measured by no-pitch vortimeters installed in each pump suction line immediately above the suction bell. The vortimeter location corresponded to the approximate location of the pump impellers in the prototype. Without splitter walls and with only one of the two circulating water pumps in operation, the vortimeter indicated rotational speeds in excess of 30 rpm. The results presented in this Addendum represent model test results with the splitter walls installed.

Table A21 shows average rpm observations when both circulating water pumps were in operation, with the splitter walls at various bottom elevations, and with one of the two turbine cooling water pumps in operation. Similar sets of experiments for the North Pump only and the South Pump only are summarized in Tables A22 and A23. Generally, the rotational averages were not constant for any of the test conditions. The values presented in the tables resulted from averaging ten individual observations. The plus and minus signs were used to indicate opposite rotational directions.

Only one of the turbine cooling water pumps will be operated at one time in prototype operation. In the laboratory, the relative effects of the turbine cooling water pumps on flow pre-rotation in the circulating water pumps were investigated with the results that the relative effects were not documentable. Table A24 shows typical experimental results and the indicated differences are not significant in light of other observed variations.

VOGTLE III--Approach Channel Velocity Distributions: The test procedures established for VOGTLE II models were also used for the VOGTLE III models. Again, a 1:40 scale model was built and tested. The test results were then used to "tune" the 1:8 scale model of VOGTLE III. The experience gained with previous VOGTLE models was utilized by modeling and testing VOGTLE III with splitter walls in the pump bays. The velocity measuring station designation was also retained. In VOGTLE III, the floor of the pump intake structure was at elevation 188 feet, and the normal operating water level was at 215 feet.

In the 1:8 scale VOGTLE III model, velocity measurements were made, again, at the previously established longitudinal and transverse stations, and at three different depths. Figure A42 shows the velocity measuring stations. Thus, Table A25 and Figure A43 show the velocities at two feet below the water surface when both circulating water pumps were operated; Table A26 and Figure A45 show the velocities at a depth some two feet above the channel floor.

When the North Pump only was operated, the velocity distribution for a depth of two feet below the water surface is given in Table A28 and in Figure A46, for mid-depth in Table A29 and Figure A47, and for a depth of two feet above the channel floor in Table A30 and Figure A48.

When the South Pump only was operated, the velocity distribution for a depth of two feet below the water surface is given in Table A31 and Figure A49, for mid-depth in Table A32 and Figure A50, and for a depth of two feet above the channel floor in Table A33 and Figure A51.

VOGTLE III--Pump Bell Flow Patterns: The flow patterns at the pump suction bells were studied and observed, again, by means of wool tufts attached to brass rods. Figures A52 and A53 show the flow directions at the pump suction bells of the North Pump and the South Pump when both pumps were operated. Figure A54 shows the flow directions when the North Pump only was operated, and Figure A55 shows the flow directions when the South Pump only was operated.

VOGTLE III--Pre-rotation in Suction Lines: Without splitter walls and with one pump in operation, the pre-rotation of the flow in the suction lines registered in excess of 30 rpm. The data presented in this report were taken when the splitter walls were installed. One additional feature was added to the model at this stage. This feature was three guide vanes on the pump bell surface (see Figure A13). Tables A34, A35, and A36 show typical model test results. Positive revolutions are clockwise when viewed in the direction of flow.

Another test sequence was made on VOGTLE III with a different floor arrangement. In order to differentiate the results obtained for this alternate floor scheme, the model was designated as VOGTLE IV. The plan view of VOGTLE IV is shown in Figure A56 and the elevation view in Figure A57.

VOGTLE IV--Approach Channel Velocity Distribution: Following previously established test procedures, the velocity distributions in the approach channel of the 1:8 scale VOGTLE IV model were measured. The results are summarized in Tables A37 through A45 and Figures A58 through A66.

Accordingly, Table A37 and Figure A58 show the velocity distribution in the approach channel at a depth of two feet below the water surface when both circulating water pumps were in operation. Table A38 and Figure A59 show the velocities at mid-depth for the same pump flow rates, and Table A39 and Figure A60 show the velocities at a depth of two feet above the channel floor.

When the North Pump <u>only</u> was operated, the resulting velocity distributions are shown in Table A40 and Figure A61 for a depth of two feet below the water surface, in Table A41 and Figure A62 for mid-depth, and in Table A42 and Figure A63 for a depth of two feet above the channel floor.

When the South Pump <u>only</u> was operated, the resulting velocity distributions are shown in Table A43 and Figure A64 for a depth of two feet below the water surface, in Table A44 and Figure A65 for mid-depth, and in Table A45 and Figure A66 for a depth of two feet above the channel floor.

<u>VOGTLE IV--Flow Pre-rotation in Suction Lines</u>: Without splitter walls in the pump bays and with only one of the two circulating water pumps in operation, the pre-rotation in the pump suction lines was in excess of 30 rpm. The data presented for the 1:8 scale model VOGTLE IV were for test conditions with the splitter wall in place. Thus, Table A46 represents observed revolutions in the model when both circulating water pumps were in operation. Table A47 represents data for the North Pump <u>only</u>, and Table A48 represents data for the South Pump <u>only</u>.

VI. Conclusions and Recommendations

This report represents an Addendum to the Final Report on the VOGTLE Nuclear Hydraulic Model Studies, published in January 1978. The Addendum contains model test results on three different approach channel geometrics, and these schemes were labeled VOGTLE II, VOGTLE III, and VOGTLE IV.

All VOGTLE model schemes had typically two-bay pump intake structures. Each bay housed one circulating water pump and one turbine cooling water pump. The nominal flow rate for the circulating water pumps in some 244,000 gpm and for the turbine cooling water pumps some 14,000 gpm, the tests were conducted with flow rates of 270,000 gpm and 16,000 gpm, respectively. The VOGTLE II model was characterized by a trapezoidal approach channel. The VOGTLE III and VOGTLE IV models had rectangular approach channels.

The resulting flow patterns were reported in tables and graphs for three areas. These were the velocity distributions in the approach channels, flow directions in the proximity of the pump suction bells, and flow pre-rotation in the pump suction lines.

The model tests verified the advantages of the two-bay model over the original three-bay model.

VOGTLE II, III and IV models performed very satisfactorily when both circulating water pumps were in operation. When only one of the pumps was operated, either the North Pump only or the South Pump only, the asymmetrical inflows into the pump intake structure resulted in flow pre-rotation in the active pump suction line. Under these conditions, there were no observable free-surface vortices, although there was a slow general circulation around the pump barrel.

When splitter walls were introduced at the back wall of each pump bay, the general circulation was inhibited and the pre-rotation of the flow in the suction lines was dramatically reduced. The splitter walls consisted of thin vertical members some 4 to 6 inches thick and extending some 28 inches away from the back wall. The splitter walls were centered in the bay and extended vertically from the normal operating water level down to the proximity of the pump bell. For reasons of practicality, the thickness of the splitter wall could be increased without decreasing its effectiveness in inhibiting flow pre-rotation. Extending the splitter wall to the elevation of the pump suction bell should be satisfactory.

Some additional variation in geometry may become a requirement of the Plant Vogtle Cooling Water System. The model tests showed that the two-bay pump intake structure should be retained. Minor changes in the channel geometries should not invalidate the model test results provided that the changes result in either or both a reduction of the approach flow velocities and an increase of pump submergence.

The insertion of a splitter wall into the pump bays was by far the most important design modification discovered by the model tests. The splitter wall should be included into the final design of the pump intake structure of the Plant Vogtle Circulating Water System.

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Table A3. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II Channel Area Only

North and South Pumps

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 a	(G)	0.7	1.3	Velocity measurements at an equivalent depth of 2 ft below water surface(**).
b		2.0	2.1	
c		1.5	1.8	
36 a		1.2	1.6	Both pumps operated at Q = 600 cfs each pump.
b		1.8	2.0	
c		1.5	1.9	
40 a	(F)	1.6	1.4	
b		1.7	1.8	
c		1.7	1.8	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A4. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II Channel Area Only

North and South Pumps

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 b	(G)	1.8	2.0	Velocity measurements at mid-depth(**).
36 b		1.7	2.0	
40 b	(F)	1.6	2.0	Q = 600 cfs each pump.

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A5. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II Channel Area Only

North and South Pumps

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 a	(G)	1.0	1.9	Velocity measurements at 2 ft above floor(**).
b		1.6	1.8	
c		2.0	1.6	
36 a		1.5	1.7	Q = 600 cfs each pump.
b		1.6	2.1	
c		1.7	1.6	
40 a	(F)	1.6	1.6	
b		1.7	2.0	
c		1.8	1.5	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A6. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II Channel Area Only

North Pump Only

Model Station(*)	1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 a (G)	0.4	0.7	Velocity measurements at 2 ft below water surface(**).
b	0.9	0.9	
c	0.6	0.9	
36 a	0.5	0.6	Q = 600 cfs, North Pump Only.
b	0.7	1.0	
c	0.9	0.9	
40 a (F)	0.7	0.7	
b	0.7	0.9	
c	0.9	0.9	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A7. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II Channel Area Only

North Pump Only

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 b	(G)	0.6	1.0	Velocity measurements at mid-depth below water surface(**).
36 b		0.7	1.0	
40 b	(F)	0.7	1.0	Q = 600 cfs, North Pump <u>Only</u>.

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A8. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II
Channel Area Only

North Pump Only

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 a	(G)	0.6	0.8	Velocity measurements at
b		0.6	1.0	2 ft above floor(**).
c		0.7	0.9	
36 a		0.6	0.7	Q = 600 cfs, North Pump Only.
b		0.6	1.0	
c		0.9	0.9	
40 a	(F)	0.6	0.7	
b		0.8	1.0	
c		0.9	0.9	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A9. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II
Channel Area Only

South Pump Only

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34	a	0.3	0.5	Velocity measurements at 2 ft below water surface(**).
	b	0.9	1.0	
	c	0.5	0.8	
36	a	0.7	0.5	Q = 600 cfs, South Pump Only.
	b	0.8	0.9	
	c	0.6	0.8	
40	a	0.9	0.6	
	b	0.7	0.8	
	c	0.6	0.8	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A10. Velocity Profile Comparison of 1:8 Scale Model to 1:40 Scale Model, VOGTLE II
Channel Area Only

South Pump Only

Model Station(*)		1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 b	(G)	0.7	0.9	Velocity measurements at mid-depth below water surface(**).
36 b		0.7	0.9	
40 b	(F)	0.7	1.0	Q = 600 cfs, South Pump Only.

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A11. Velocity Profile Comparison of 1:8 Scale Model
to 1:40 Scale Model, VOGTLE II
Channel Area Only

South Pump Only

Model Station(*)	1:8 Prototype Velocities ft/sec	1:40 Prototype Velocities ft/sec	Comments
34 a (G)	0.6	0.7	Velocity measurements at 2 ft above floor surface(**).
b	0.9	0.9	
c	0.8	0.8	
36 a	0.8	0.7	Q = 600 cfs, South Pump <u>Only</u>.
b	0.8	0.9	
c	0.8	0.8	
40 a (F)	1.0	0.8	
b	0.7	1.0	
c	0.8	0.7	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.

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Table A12. Velocity Profile in 1:8 Scale Model, VOGTLE II
North and South Pumps

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	0.6	The following are taken at an equivalent depth of 2 feet below water surface(**).
	2	0.3	
	3	1.0	
	4	1.0	
	5	0.2	
	6	0.9	
B	1	1.2	Both pumps at 600 cfs each.
	2	1.2	
	3	1.2	Turbine cooling pump running pulling from South Bay Only.
	4	1.4	
	5	1.4	
	6	1.2	
C	1	1.2	
	2	1.2	
	3	1.1	
	4	1.4	
	5	1.3	
	6	1.2	
D	1	1.3	
	2	1.3	
	3	1.4	
	4	1.5	
E	1	1.6	
	2	1.6	
	3	1.6	
F	1	-	
	2	1.8	
	3	-	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.
Pump floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A13. Velocity Profile in 1:8 Scale Model, VOGTLE II North and South Pumps

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.1	The following are taken at an equivalent depth of 13 feet below water surface stations A, B, and C (**).
	2	1.2	
	3	1.2	
	4	1.3	
	5	1.3	
	6	1.3	
B	1	1.3	Depth of 11 feet below water surface for station D.
	2	1.2	
	3	1.3	
	4	1.4	
	5	1.4	Both pumps at 600 cfs each.
	6	1.4	
C	1	1.3	Turbine cooling pump running pulling from South Bay Only.
	2	1.2	
	3	1.2	
	4	1.3	
	5	1.3	
	6	1.5	
D	1	1.4	
	2	1.3	
	3	1.3	
	4	1.3	
E	1	-	
	2	-	
	3	-	
F	1	-	
	2	-	
	3	-	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A14. Velocity Profile in 1:8 Scale Model, VOGTLE II North and South Pumps

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.5	The following are taken at an equivalent depth of 2 feet above floor surface(**).
	2	1.8	
	3	1.5	
	4	1.6	
	5	1.8	
	6	1.5	
B	1	1.1	Floor elevation of station E_1 and E_3 = 197 feet.
	2	0.9	
	3	1.0	
	4	1.2	Floor elevation of station F_1 and F_3 = 198 feet.
	5	1.1	
	6	1.3	
C	1	0.9	Both pumps at 600 cfs each.
	2	0.6	
	3	0.5	Turbine cooling pump running pulling from South Bay Only.
	4	0.7	
	5	0.8	
	6	1.1	
D	1	0.7	
	2	0.9	
	3	0.9	
	4	0.7	
E	1	1.5	
	2	1.4	
	3	1.7	
F	1	1.7	
	2	1.7	
	3	1.9	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A15. Velocity Profile in 1:8 Scale Model, VOGTLE II
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.2	The following are taken at an equivalent depth of 2 feet below water surface(**).
	2	0.3	
	3	0.5	
B	1	1.5	North Pump Only at 600 cfs.
	2	1.6	
	3	1.2	
C	1	1.2	Turbine cooling pump running pulling from South Bay Only.
	2	1.3	
	3	1.5	
	4	0.6	
	5	0.2	
	6	0.0	
D	1	1.0	
	2	0.6	
	3	0.8	
	4	0.6	
E	1	0.9	
	2	0.8	
	3	1.1	
F	1	-	
	2	0.8	
	3	-	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.
Pump floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A16. Velocity Profile in 1:8 Scale Model, VOGTLE II
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.2	The following are taken at an equivalent depth of 13 feet below water surface--stations A, B, and C(**).
	2	1.2	
	3	1.3	
B	1	1.4	
	2	1.6	Depth of 11 feet below water surface for station D.
	3	1.0	
C	1	1.1	
	2	1.2	
	3	1.5	North Pump Only at 600 cfs.
	4	0.6	
	5	0.6	Turbine cooling pump running pulling from South Bay Only.
	6	0.0	
D	1	0.8	
	2	0.6	
	3	0.6	
	4	0.8	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A17. Velocity Profile in 1:8 Scale Model, VOGTLE II
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.9	The following are taken at an equivalent depth of 2 feet above floor surface(**).
	2	1.9	
	3	1.3	
B	1	1.3	Floor elevation of station E_1 and E_3 = 197 feet.
	2	1.6	
	3	0.7	
C	1	0.8	Floor elevation of station F_1 and F_3 = 198 feet.
	2	1.3	
	3	1.5	
	4	0.7	North Pump Only at 600 cfs.
	5	0.3	
	6	0.0	Turbine cooling pump running pulling from South Bay Only.
D	1	0.6	
	2	0.6	
	3	0.6	
	4	0.5	
E	1	0.9	
	2	0.6	
	3	1.0	
F	1	1.2	
	2	0.7	
	3	1.1	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A18. Velocity Profile in 1:8 Scale Model, VOGTLE II
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	4	0.4	The following are taken at an equivalent depth of 2 feet below water surface(**).
	5	0.5	
	6	1.3	
B	4	0.4	South Pump Only at 600 cfs.
	5	1.5	
	6	1.6	Turbine cooling pump running pulling from South Bay Only.
C	1	0.0	
	2	0.0	
	3	0.3	
	4	1.1	
	5	1.2	
	6	1.3	
D	1	0.6	
	2	0.6	
	3	0.6	
	4	0.8	
E	1	1.0	
	2	0.8	
	3	0.9	
F	1	-	
	2	0.9	
	3	-	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet.
Pump floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A19. Velocity Profile in 1:8 Scale Model, VOGTLE II
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	4	0.6	The following are taken at an equivalent depth of 13 feet below water surface--stations A, B, and C(**).
	5	1.5	
	6	1.6	
B	4	0.5	
	5	1.7	Depth of 11 feet below water surface for station D.
	6	1.6	
C	1	0.2	
	2	0.4	South Pump Only at 600 cfs.
	3	0.6	
	4	1.2	Turbine cooling pump running pulling from South Bay Only.
	5	1.3	
	6	1.3	
D	1	0.7	
	2	0.6	
	3	0.6	
	4	0.8	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

PLANT VOGTLE PROJECT
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Table A20. Velocity Profile in 1:8 Scale Model, VOGTLE II
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	4	1.3	The following are taken at an equivalent depth of 2 feet above floor surface(**).
	5	2.1	
	6	1.9	
B	4	0.8	Floor elevation of station E_1 and E_3 = 197 feet.
	5	1.7	
	6	1.5	
C	1	0.0	Floor elevation of station F_1 and F_3 = 198 feet.
	2	0.2	
	3	0.5	
	4	1.2	South Pump Only at 600 cfs.
	5	1.2	
	6	1.1	Turbine cooling pump running pulling from South Bay Only.
D	1	0.3	
	2	0.6	
	3	0.5	
	4	0.7	
E	1	0.9	
	2	0.7	
	3	1.0	
F	1	1.1	
	2	0.9	
	3	0.9	

(*) See definition sketch, Figure A15.

(**) Water surface elevation at pump intake station = 214 feet. Pump floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A21. Vortimeter Study in 1:8 Scale Model, VOGTLE II
Splitter Wall in Pump Bays, North and South Pumps

Turbine Cooling Pump	Splitter Wall, Bottom Elev.	Avg. North Turns/60 sec	Avg. South Turns/60 sec
North	195	-4.3	+4.5
North	195	-5.1	+4.2
South	195	-3.1	+2.7
South	195	-3.1	+2.6
North	192	-4.8	+3.4
North	192	-3.1	+3.8
South	192	-4.7	+3.1
South	192	-4.4	+3.1
North	188	-2.1	+9.1
North	188	-2.7	+6.6
South	188	-2.4	+7.6
South	188	-2.6	+5.9

Both pumps at 600 cfs each.

Water surface elevation in pump bays = 214 feet

- sign - counter-clockwise rotation

+ sign - clockwise rotation

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A22. Vortimeter Study in 1:8 Scale Model, VOGTLE II Splitter Wall in Pump Bays, North Pump Only

Turbine Cooling Pump	Splitter Wall, Bottom Elev.	Avg. North Turns/60 sec +	-
North	188	1.3	0.1
North	188	1.3	0.4
South	188	0.8	0.3
South	188	1.1	0.4
North	192	5.1	0
South	192	1.9	0.2
North	195	6.8	0
South	195	3.8	0

North Pump Only at 600 cfs.

Water surface elevation in pump bays = 214 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A23. Vortimeter Study in 1:8 Scale Model, VOGTLE II
Splitter Wall in Pump Bays, South Pump Only

Turbine Cooling Pump	Splitter Wall, Bottom Elev.	Avg. South Turns/60 sec +	-
North	188	0.3	0.8
South	188	0.1	1.2
North	192	0	4.8
South	192	0	7.3
North	195	0	4.2
South	195	0	7.1

South Pump <u>Only</u> at 600 cfs.

Water surface elevation in pump bays = 214 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A24. Vortimeter Study in 1:8 Scale Model, VOGTLE II
Splitter Walls Installed, Both Pumps Running

Run	NORTH PUMP Rpm's +	NORTH PUMP Rpm's -	SOUTH PUMP Rpm's +	SOUTH PUMP Rpm's -	Comments
	Cooling Turbine @ North Bay				
1	0	4	2	0	Water surface elevation 214 feet.
2	0	5	3	0	
3	0	4	1	0	Both pumps at 600 cfs each.
4	0	3	0	0	
5	0	3	2	0	
6	0	4	0	0	
7	0	4	2	0	
8	0	5	1	0	
9	0	5	2	0	
10	0	7	3	0	
Average	0	-4	+2	0	
	Cooling Turbine @ South Bay				
1	0	5	1	0	
2	0	5	1	0	
3	0	4	1	0	
4	0	5	2	0	
5	0	5	2	1	
6	0	5	2	0	
7	0	5	1	0	
8	0	4	1	0	
9	0	6	1	0	
10	0	5	0	1	
Average	0	-5	+1	0	

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A26. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III North and South Pumps

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	0.9	The following are taken at an equivalent of mid-depth (**).
	2	0.9	
	3	0.9	
	4	1.0	
	5	0.9	
	6	0.9	
B	1	0.9	Q = 600 cfs each pump.
	2	1.0	
	3	1.0	Splitter wall in place.
	4	1.0	
	5	1.0	
	6	1.1	
C	1	0.8	
	2	1.0	
	3	0.9	
	4	1.0	
	5	1.0	
	6	1.0	
D	1	1.0	
	2	1.0	
	3	1.1	
	4	1.0	
	5	1.1	
E	1	1.0	
	2	1.1	
	3	1.2	
	4	1.0	
	5	1.2	
F	1	1.0	
	2	1.3	
	3	1.4	
	4	1.1	
	5	1.2	
G	1	1.1	
	2	1.3	
	3	1.3	
	4	1.1	
	5	1.4	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A27. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III North and South Pumps

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.2	The following are taken at an equivalent depth of 2 ft above floor surface(**).
	2	1.6	
	3	1.5	
	4	1.5	
	5	1.7	
	6	1.4	
B	1	0.8	Q = 600 cfs each pump.
	2	1.0	
	3	1.1	Splitter wall in place.
	4	1.0	
	5	1.0	
	6	0.9	
C	1	0.8	
	2	0.9	
	3	0.8	
	4	0.9	
	5	0.8	
	6	0.8	
D	1	1.0	
	2	0.9	
	3	0.9	
	4	0.9	
	5	1.0	
E	1	1.0	
	2	1.1	
	3	1.1	
	4	0.8	
	5	1.0	
F	1	1.1	
	2	1.1	
	3	1.2	
	4	1.0	
	5	1.0	
G	1	1.4	
	2	1.4	
	3	1.4	
	4	1.2	
	5	1.3	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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Table A28. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	0.8	The following are taken at an equivalent of 2 ft below water surface(**).
	2	N/A	
	3	0.7	
	4	-	
	5	-	
	6	-	
B	1	1.1	Q = 600 cfs, North Pump Only.
	2	1.1	
	3	0.8	
	4	-	Splitter wall in place.
	5	-	
	6	-	
C	1	0.9	
	2	1.0	
	3	1.2	
	4	-	
	5	-	
	6	-	
D	1	0.6	
	2	0.5	
	3	0.5	
	4	0.5	
	5	0.4	
E	1	0.5	
	2	0.5	
	3	0.4	
	4	0.5	
	5	0.6	
F	1	0.5	
	2	0.5	
	3	0.5	
	4	0.5	
	5	0.6	
G	1	0.6	
	2	0.3	
	3	0.4	
	4	0.5	
	5	0.6	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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Table A29. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.1	The following are taken at an equivalent of mid-depth (**).
	2	1.2	
	3	0.9	
	4	-	
	5	-	
	6	-	
B	1	1.2	Q = 600 cfs, North Pump Only.
	2	1.2	
	3	0.7	
	4	-	Splitter wall in place.
	5	-	
	6	-	
C	1	0.9	
	2	0.9	
	3	1.2	
	4	-	
	5	-	
	6	-	
D	1	0.5	
	2	0.4	
	3	N/A	
	4	N/A	
	5	0.3	
E	1	0.5	
	2	N/A	
	3	N/A	
	4	0.5	
	5	0.5	
F	1	0.4	
	2	0.4	
	3	0.2	
	4	0.5	
	5	0.5	
G	1	0.4	
	2	0.4	
	3	0.3	
	4	0.6	
	5	0.5	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A30. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.7	The following are taken at an equivalent of 2 ft above floor level(**).
	2	1.7	
	3	1.4	
	4	-	
	5	-	
	6	-	
B	1	1.2	Q = 600 cfs, North Pump Only.
	2	0.8	
	3	0.7	
	4	-	Splitter wall in place.
	5	-	
	6	-	
C	1	0.9	
	2	1.1	
	3	1.3	
	4	0.6	
	5	-	
	6	-	
D	1	0.6	
	2	0.6	
	3	N/A	
	4	N/A	
	5	N/A	
E	1	0.5	
	2	0.5	
	3	0.5	
	4	N/A	
	5	0.6	
F	1	0.5	
	2	0.4	
	3	0.4	
	4	0.4	
	5	0.6	
G	1	0.8	
	2	0.7	
	3	0.5	
	4	0.5	
	5	0.7	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A31. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	-	The following are taken at an equivalent depth of 2 ft below surface(**).
	2	-	
	3	-	
	4	0.4	
	5	N/A	
	6	0.7	
B	1	-	Q = 600 cfs, South Pump <u>Only</u>.
	2	-	
	3	-	
	4	0.9	Splitter wall in place.
	5	1.0	
	6	0.9	
C	1	-	
	2	-	
	3	-	
	4	0.9	
	5	1.0	
	6	0.9	
D	1	0.3	
	2	0.4	
	3	0.4	
	4	0.5	
	5	0.6	
E	1	0.5	
	2	0.5	
	3	0.5	
	4	0.5	
	5	0.5	
F	1	0.6	
	2	0.4	
	3	0.5	
	4	0.5	
	5	0.5	
G	1	0.5	
	2	0.6	
	3	0.4	
	4	0.5	
	5	0.6	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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Table A32. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	-	The following are taken at an equivalent of mid-depth (**).
	2	-	
	3	-	
	4	1.0	
	5	1.0	
	6	1.0	
B	1	-	Q = 600 cfs, South Pump Only.
	2	-	
	3	-	
	4	0.6	Splitter wall in place.
	5	1.2	
	6	1.0	
C	1	-	
	2	-	
	3	-	
	4	1.2	
	5	1.1	
	6	0.9	
D	1	0.3	
	2	0.4	
	3	0.6	
	4	0.5	
	5	0.6	
E	1	0.5	
	2	0.5	
	3	0.5	
	4	0.5	
	5	0.5	
F	1	0.5	
	2	0.5	
	3	0.6	
	4	0.6	
	5	0.5	
G	1	0.4	
	2	0.7	
	3	0.6	
	4	0.6	
	5	0.5	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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Table A33. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE III
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	–	The following are taken at an equivalent depth of 2 ft above floor surface(**).
	2	–	
	3	–	
	4	1.3	
	5	1.5	
	6	1.6	
B	1	–	Q = 600 cfs, South Pump Only.
	2	–	
	3	–	
	4	0.4	Splitter wall in place.
	5	1.0	
	6	1.0	
C	1	–	
	2	–	
	3	–	
	4	1.2	
	5	0.9	
	6	0.8	
D	1	N/A	
	2	0.3	
	3	N/A	
	4	0.5	
	5	0.5	
E	1	0.4	
	2	0.5	
	3	0.5	
	4	0.5	
	5	0.4	
F	1	0.6	
	2	0.5	
	3	0.6	
	4	0.5	
	5	0.4	
G	1	0.6	
	2	0.7	
	3	0.7	
	4	0.7	
	5	0.6	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A34. Vortimeter Study in 1:8 Scale Model, VOGTLE III
Pump Suction Lines

Run	North Pump* Rev/60 sec. +	North Pump* Rev/60 sec. −	South Pump* Rev/60 sec. +	South Pump* Rev/60 sec. −	Comments
1	-	1	2	-	Water level at 215 feet.
2	-	1	4	-	Bell vanes installed.
3	-	1	4	-	Splitter walls in place.
4	-	1	2	-	Both pumps at "design" flow.
5	-	-	3	-	
6	-	2	4	-	
7	-	1	3	-	
8	-	1	2	-	
9	-	-	2	-	
10	-	1	2	-	
Average	-	-1	+3	-	

*Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A35. Vortimeter Study in 1:8 Scale Model, VOGTLE III
Pump Suction Lines

Run	North Pump* Rev/60 sec. +	North Pump* Rev/60 sec. -	South Pump* Rev/60 sec. +	South Pump* Rev/60 sec. -	Comments
1	2	-	-	-	Water level at 215 feet.
2	3	-	-	-	Splitter wall in place.
3	2	-	-	-	North Pump Only.
4	3	-	-	-	
5	1	-	-	-	
6	3	-	-	-	
7	2	-	-	-	
8	3	-	-	-	
9	3	-	-	-	
10	3	-	-	-	
Average	+3	-	-	-	

*Positive revolutions are clockwise looking in the direction of flow.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A36. Vortimeter Study in 1:8 Scale Model, VOGTLE III
Pump Suction Lines

	North Pump* Rev/60 sec.		South Pump* Rev/60 sec.		
Run	+	-	+	-	Comments
1	-	-	2	-	Water level at 215 feet.
2	-	-	2	-	Bell vanes installed.
3	-	-	5	-	Splitter wall in place.
4	-	-	2	-	South Pump Only.
5	-	-	1	-	
6	-	-	2	-	
7	-	-	2	-	
8	-	-	1	-	
9	-	-	2	-	
10	-	-	1	-	
Average	-	-	+2	-	

*Positive revolutions are clockwise looking in the direction of flow.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A37. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV Both North and South Pumps at Design Flow

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	0.7	The following are taken at an equivalent of 2 feet below water surface(**).
	2	N/A	
	3	0.7	
	4	0.8	
	5	N/A	
	6	0.8	
B	1	0.8	Both pumps operating at "design" flow.
	2	0.9	
	3	0.7	
	4	0.8	Q = 600 cfs each pump.
	5	1.0	
	6	0.9	
C	1	0.8	
	2	0.9	
	3	0.9	
	4	0.9	
	5	1.0	
	6	1.1	
D	1	1.2	
	2	1.1	
	3	0.9	
	4	1.1	
	5	1.2	
E	1	1.6	
	2	1.4	
	3	1.3	
	4	1.3	
	5	1.4	
F	1	1.9	
	2	1.8	
	3	1.7	
	4	1.6	
	5	1.9	
G	1	1.8	
	2	1.8	
	3	1.7	
	4	1.7	
	5	1.9	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet. Floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A38. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV Both North and South Pumps at Design Flow

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.0	The following are taken at an equivalent of mid-depth of station(**).
	2	1.0	
	3	1.0	
	4	0.8	
	5	1.0	
	6	1.0	
B	1	1.1	Both pumps operating at "design" flow.
	2	1.2	
	3	1.2	
	4	1.1	Q = 600 cfs each pump.
	5	1.0	
	6	1.0	
C	1	0.8	
	2	1.1	
	3	0.8	
	4	1.0	
	5	1.0	
	6	1.1	
D	1	1.1	
	2	1.2	
	3	1.1	
	4	1.0	
	5	1.1	
E	1	1.3	
	2	1.5	
	3	1.2	
	4	1.3	
	5	1.6	
F	1	1.9	
	2	1.9	
	3	1.7	
	4	1.7	
	5	1.9	
G	1	2.0	
	2	1.9	
	3	1.8	
	4	1.7	
	5	2.1	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet. Floor elevation = 188 feet.

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CIRCULATION WATER PUMP INTAKE STUDY

Table A39. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
Both North and South Pumps at Design Flow

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.2	The following are taken at an equivalent of 2 feet above floor surface(**).
	2	1.7	
	3	1.7	
	4	1.6	
	5	2.1	
	6	1.1	
B	1	0.6	Both pumps operating at "design" flow.
	2	0.9	
	3	0.9	
	4	1.0	Q = 600 cfs each pump.
	5	0.8	
	6	0.8	
C	1	0.2	
	2	0.6	
	3	0.7	
	4	0.8	
	5	0.6	
	6	0.5	
D	1	0.4	
	2	1.1	
	3	1.0	
	4	0.7	
	5	0.6	
E	1	1.2	
	2	1.6	
	3	1.4	
	4	1.1	
	5	1.1	
F	1	1.9	
	2	2.0	
	3	1.9	
	4	1.7	
	5	1.7	
G	1	2.0	
	2	2.0	
	3	1.9	
	4	1.9	
	5	1.9	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet. Floor elevation = 188 feet.

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Table A40. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	0.7	The following are taken at an equivalent of 2 feet below water surface(**).
	2	N/A	
	3	0.6	
	4	-	
	5	-	
	6	-	
B	1	1.1	Q = 600 cfs each pump.
	2	1.2	
	3	0.8	Splitter wall in place.
	4	-	
	5	-	
	6	-	
C	1	0.9	
	2	0.9	
	3	1.2	
	4	0.5	
	5	N/A	
	6	N/A	
D	1	0.8	
	2	0.8	
	3	0.7	
	4	0.6	
	5	0.3	
E	1	0.8	
	2	0.7	
	3	0.8	
	4	0.7	
	5	0.8	
F	1	1.0	
	2	0.9	
	3	0.8	
	4	0.9	
	5	0.9	
G	1	1.0	
	2	0.8	
	3	0.8	
	4	0.8	
	5	0.8	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.
Floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A41. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.1	The following are taken at an equivalent of mid-depth of station(**).
	2	1.1	
	3	0.8	
	4	-	
	5	-	
	6	-	
B	1	1.1	Q = 600 cfs.
	2	1.2	
	3	1.1	Splitter wall in place.
	4	-	
	5	-	
	6	-	
C	1	0.9	
	2	1.0	
	3	1.1	
	4	0.4	
	5	0.1	
	6	0.1	
D	1	0.7	
	2	0.6	
	3	0.7	
	4	0.5	
	5	0.5	
E	1	0.8	
	2	0.7	
	3	0.8	
	4	0.8	
	5	0.8	
F	1	1.0	
	2	0.8	
	3	0.8	
	4	0.9	
	5	0.9	
G	1	1.0	
	2	0.9	
	3	0.8	
	4	0.8	
	5	1.0	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.
Floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A42. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
North Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	1.6	The following are taken at an equivalent of 2 feet above floor surface(**).
	2	1.7	
	3	1.2	
	4	-	
	5	-	
	6	-	
B	1	1.0	Q = 600 cfs.
	2	1.1	
	3	0.7	Splitter wall in place.
	4	-	
	5	-	
	6	-	
C	1	0.8	
	2	1.0	
	3	1.2	
	4	0.4	
	5	N/A	
	6	N/A	
D	1	0.5	
	2	0.4	
	3	0.3	
	4	0.3	
	5	0.1	
E	1	0.5	
	2	0.8	
	3	0.5	
	4	0.8	
	5	0.6	
F	1	0.9	
	2	1.1	
	3	0.8	
	4	1.0	
	5	1.0	
G	1	1.1	
	2	1.1	
	3	0.9	
	4	1.0	
	5	1.0	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.
Floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A43. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	-	The following are taken at an equivalent of 2 feet below water surface(**).
	2	-	
	3	-	
	4	0.6	
	5	N/A	
	6	0.8	
B	1	-	Q = 600 cfs.
	2	-	
	3	-	
	4	0.9	
	5	1.1	
	6	1.2	
C	1	0.1	
	2	0.3	
	3	0.6	
	4	1.0	
	5	1.0	
	6	1.1	
D	1	0.5	
	2	0.7	
	3	0.7	
	4	0.8	
	5	0.8	
E	1	0.8	
	2	0.8	
	3	0.8	
	4	0.8	
	5	0.8	
F	1	1.0	
	2	0.9	
	3	0.9	
	4	0.9	
	5	1.0	
G	1	1.0	
	2	1.1	
	3	1.0	
	4	0.7	
	5	1.0	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet. Floor elevation = 188 feet.

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Table A44. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV
South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	-	The following are taken at an equivalent of mid-depth of station(**).
	2	-	
	3	-	
	4	0.9	
	5	1.1	
	6	0.9	
B	1	-	Q = 600 cfs.
	2	-	
	3	-	Splitter wall in place.
	4	0.8	
	5	1.3	
	6	1.1	
C	1	0.1	
	2	0.1	
	3	0.5	
	4	1.0	
	5	1.1	
	6	1.0	
D	1	0.4	
	2	0.7	
	3	0.7	
	4	0.7	
	5	0.7	
E	1	0.8	
	2	0.8	
	3	0.8	
	4	0.8	
	5	0.8	
F	1	1.0	
	2	0.9	
	3	0.9	
	4	0.8	
	5	1.0	
G	1	0.9	
	2	1.0	
	3	1.0	
	4	1.0	
	5	1.0	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet.
Floor elevation = 188 feet.

PLANT VOGTLE PROJECT
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Table A45. Velocities in Approach Channel in 1:8 Scale Model, VOGTLE IV South Pump Only

Model Station(*)		Prototype Velocities ft/sec	Comments
A	1	-	The following are taken at an equivalent of 2 feet above floor surface(**).
	2	-	
	3	-	
	4	1.1	
	5	1.8	
	6	1.6	
B	1	-	Q = 600 cfs.
	2	-	
	3	-	Splitter wall in place.
	4	0.6	
	5	1.1	
	6	1.0	
C	1	N/A	
	2	0.1	
	3	0.3	
	4	1.1	
	5	0.9	
	6	0.8	
D	1	0.1	
	2	0.1	
	3	0.4	
	4	0.4	
	5	0.3	
E	1	0.6	
	2	0.8	
	3	0.7	
	4	0.6	
	5	0.6	
F	1	1.0	
	2	1.0	
	3	1.0	
	4	0.8	
	5	0.9	
G	1	1.1	
	2	1.0	
	3	1.0	
	4	0.9	
	5	1.0	

(*) See definition sketch, Figure A42.

(**) Water surface elevation at pump intake station = 215 feet. Floor elevation = 188 feet.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A46. Vortimeter Study in 1:8 Scale Model, VOGTLE IV Pump Suction Lines

Run	North Pump* Rev/60 sec. +	North Pump* Rev/60 sec. -	South Pump* Rev/60 sec. +	South Pump* Rev/60 sec. -	Comments
1	2	0	0	2	Both pumps operating at "design" flow.
2	0	0	0	3	
3	0	0	0	2	Splitter wall in place.
4	1	0	0	4	
5	2	0	0	2	
6	1	0	0	5	
7	2	0	0	3	
8	1	0	0	3	
9	2	0	0	3	
10	1	0	0	3	
Average	+1	0	0	-3	

*Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A47. Vortimeter Study in 1:8 Scale Model, VOGTLE IV Pump Suction Lines

Run	North Pump* Rev/60 sec. +	North Pump* Rev/60 sec. -	South Pump* Rev/60 sec. +	South Pump* Rev/60 sec. -	Comments
1	7	0	-	-	North Pump Only, operating at "design" flow.
2	10	0	-	-	
3	8	0	-	-	Splitter wall in place.
4	10	0	-	-	
5	8	0	-	-	
6	9	0	-	-	
7	9	0	-	-	
8	8	0	-	-	
9	10	0	-	-	
10	7	0	-	-	
Average	+9	-0	-	-	

*Positive revolutions are clockwise looking in the direction of flow.

PLANT VOGTLE PROJECT
CIRCULATION WATER PUMP INTAKE STUDY

Table A48. Vortimeter Study in 1:8 Scale Model, VOGTLE IV Pump Suction Lines

Run	North Pump* Rev/60 sec. +	North Pump* Rev/60 sec. -	South Pump* Rev/60 sec. +	South Pump* Rev/60 sec. -	Comments
1	-	-	0	8	South Pump Only operating at "design" flow.
2	-	-	0	7	
3	-	-	0	6	Water level at 215 feet.
4	-	-	0	7	Splitter wall in place.
5	-	-	0	10	
6	-	-	0	10	
7	-	-	0	8	
8	-	-	0	6	
9	-	-	0	9	
10	-	-	0	9	
Average	-	-	+0	-8	

*Positive revolutions are clockwise looking in the direction of flow.

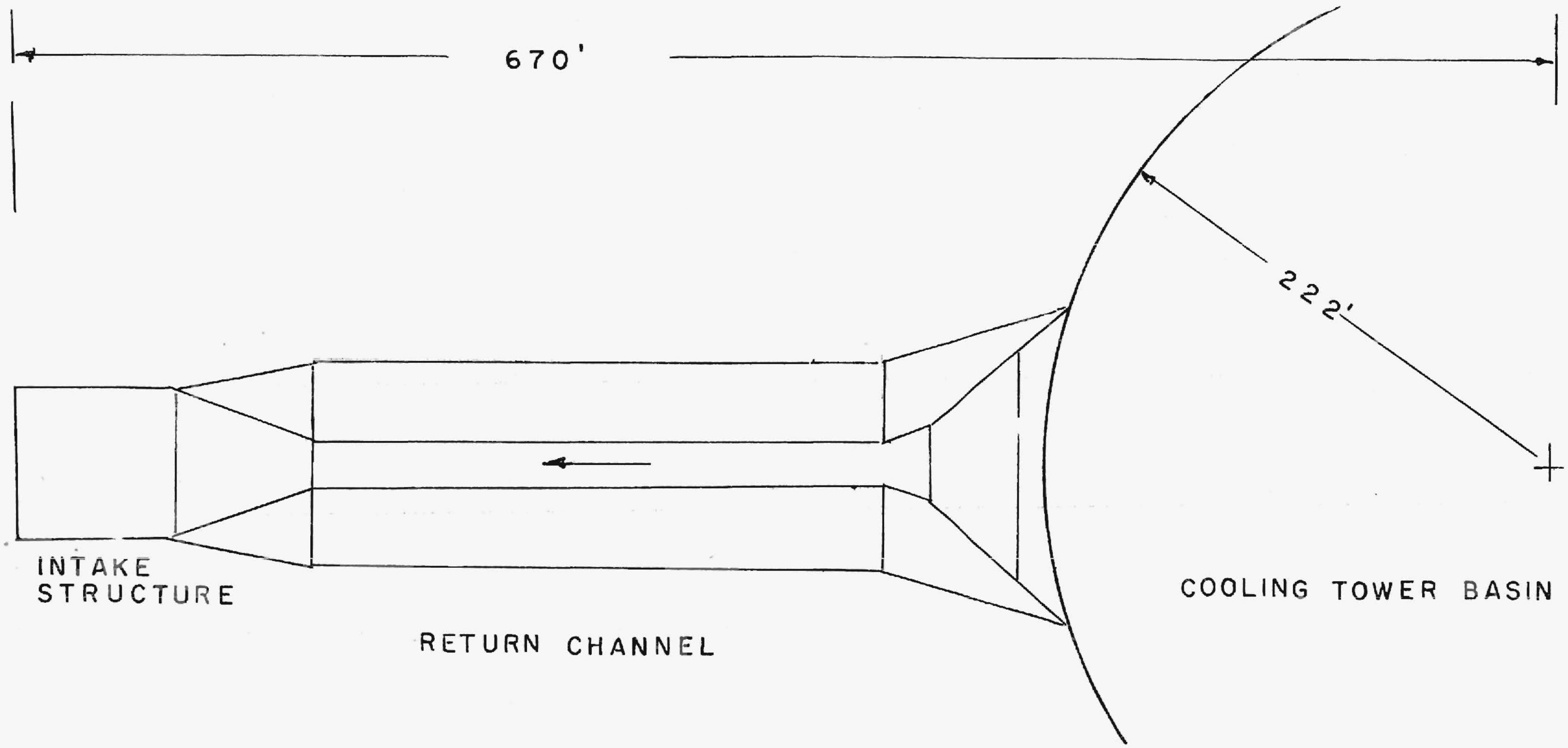


Figure A1. Schematic of Circulating Cooling Water System, Plant Vogtle.

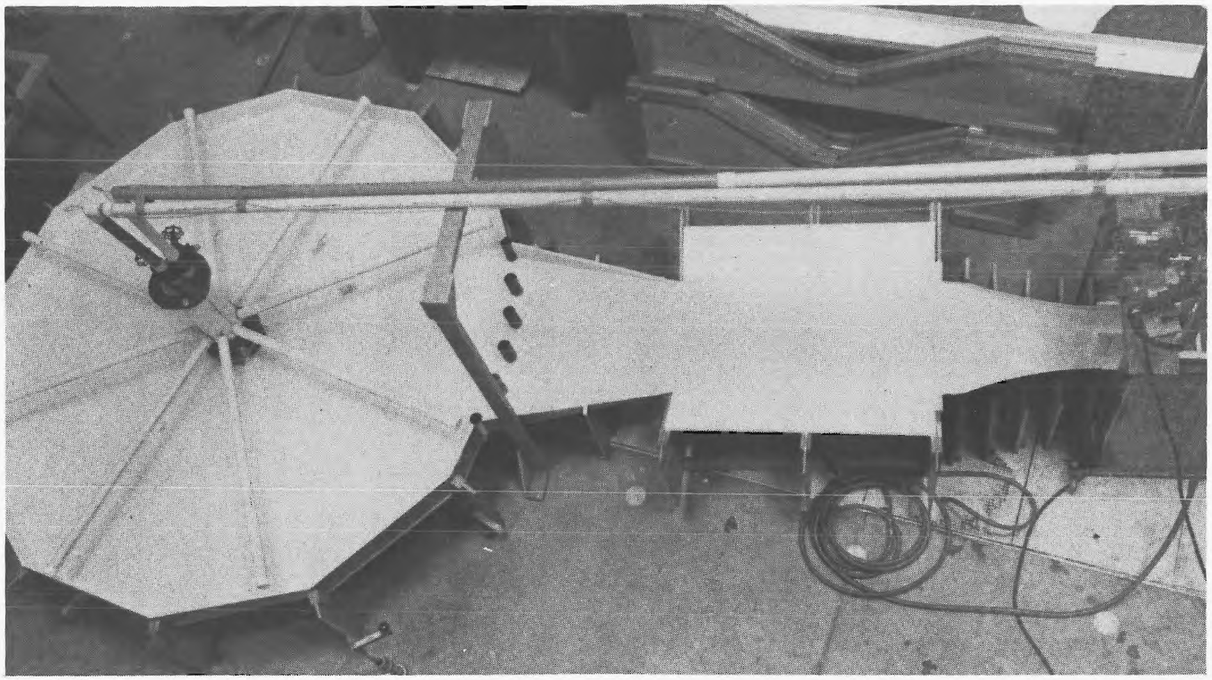


Figure A2. Vogtle II 1:40 Model.
Birds-Eye View in Lab.

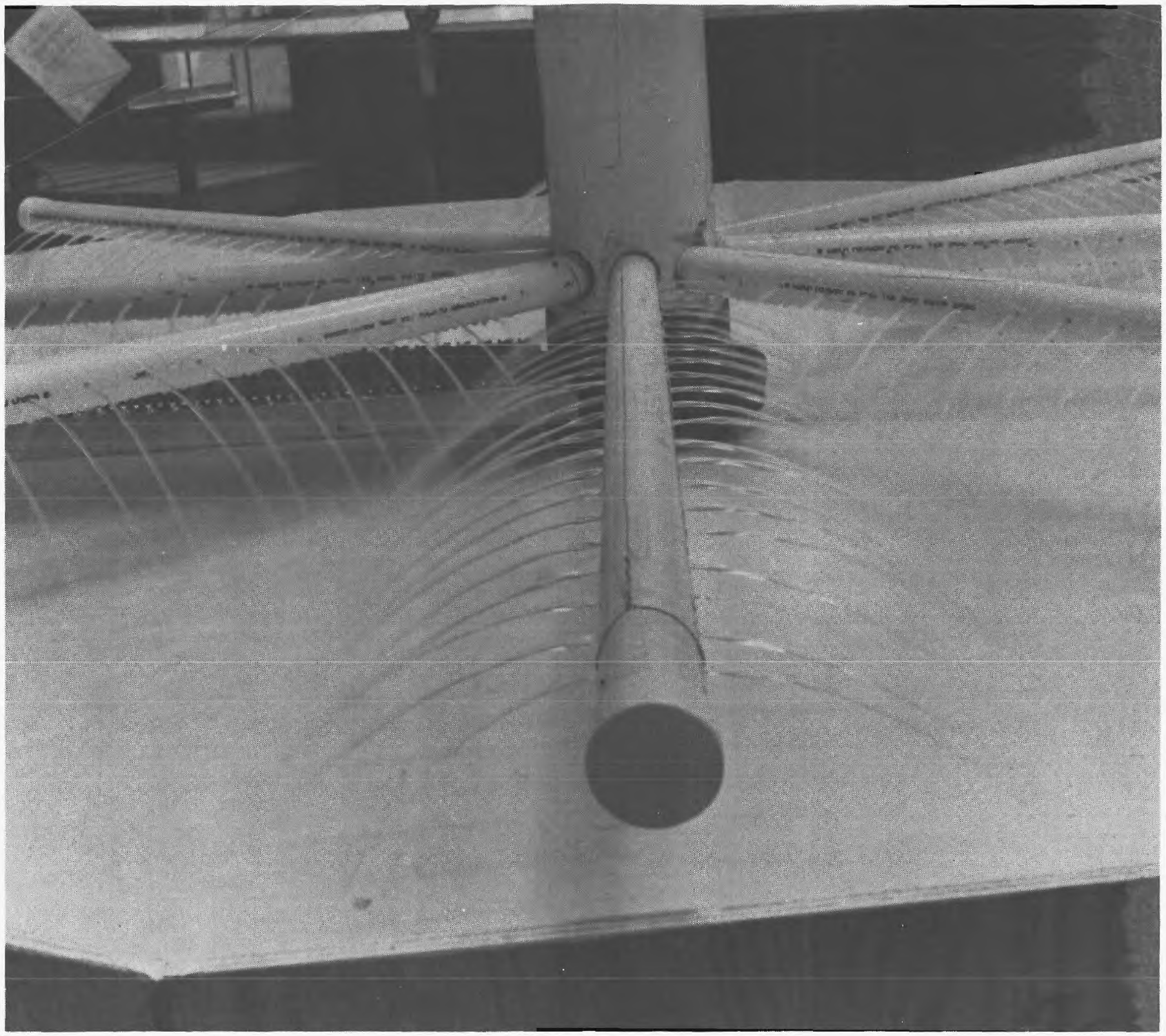


Figure A3. Vogtle II 1:40 Model.
Tower Basin in Operation.

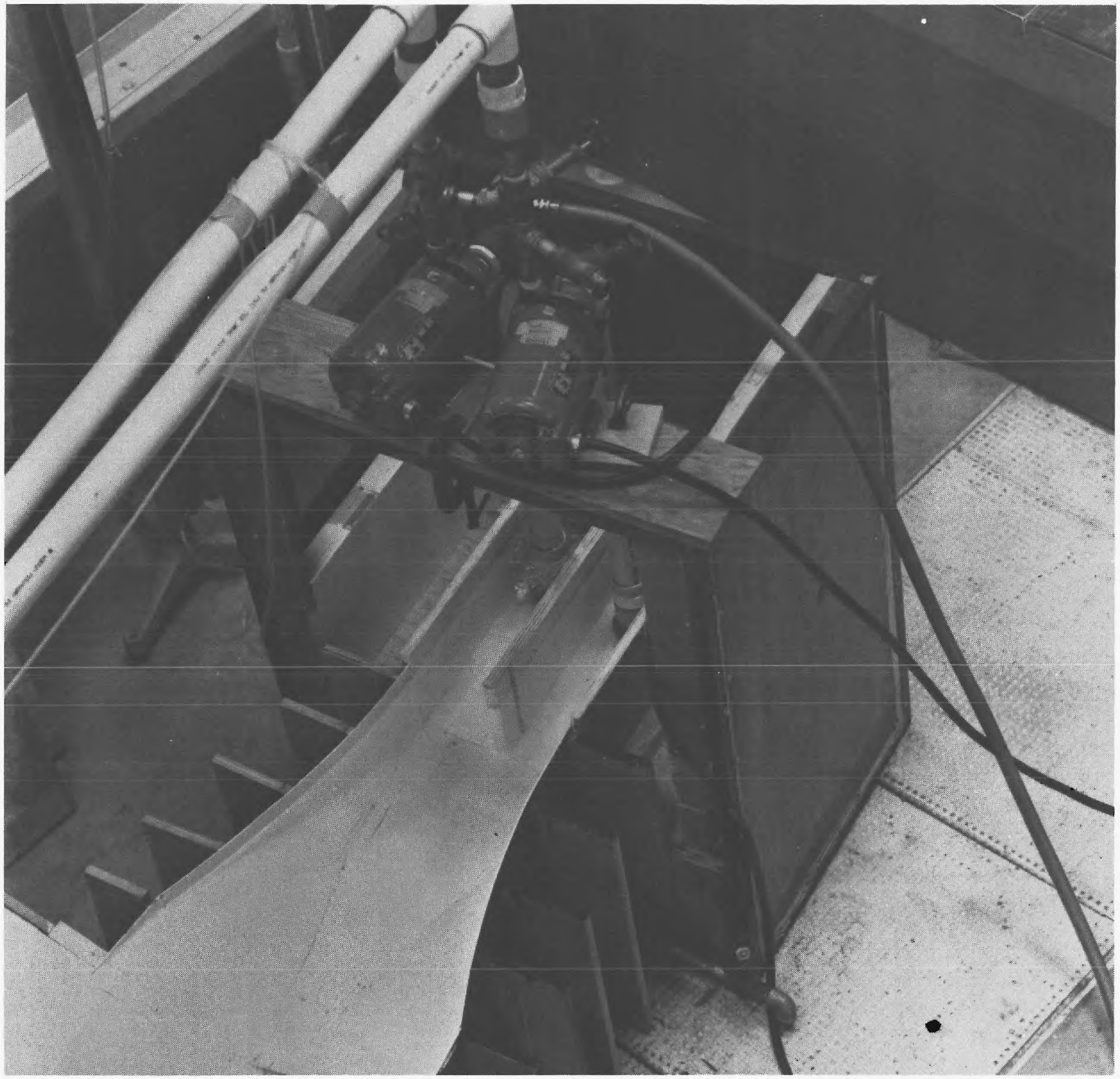
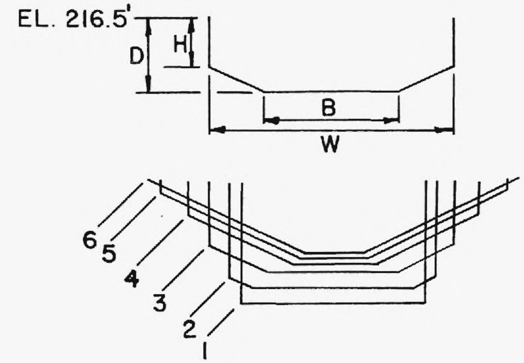


Figure A4. Vogtle II 1:40 Model.
Transition and Intake Structure.

CROSS-SECTION NUMBER	BOTTOM ELEV. FT.	DIMENSIONS, FT			
		B	W	D	H
1	188.0	43.0	43.0	28.5	28.5
2	192.0	37.0	47.0	24.5	22.0
3	196.0	31.0	56.0	20.5	14.25
4	197.0	20.0	67.0	19.5	7.75
5	197.5	14.0	80.0	19.0	2.5
6	198.0	12.0	86.0	18.5	0



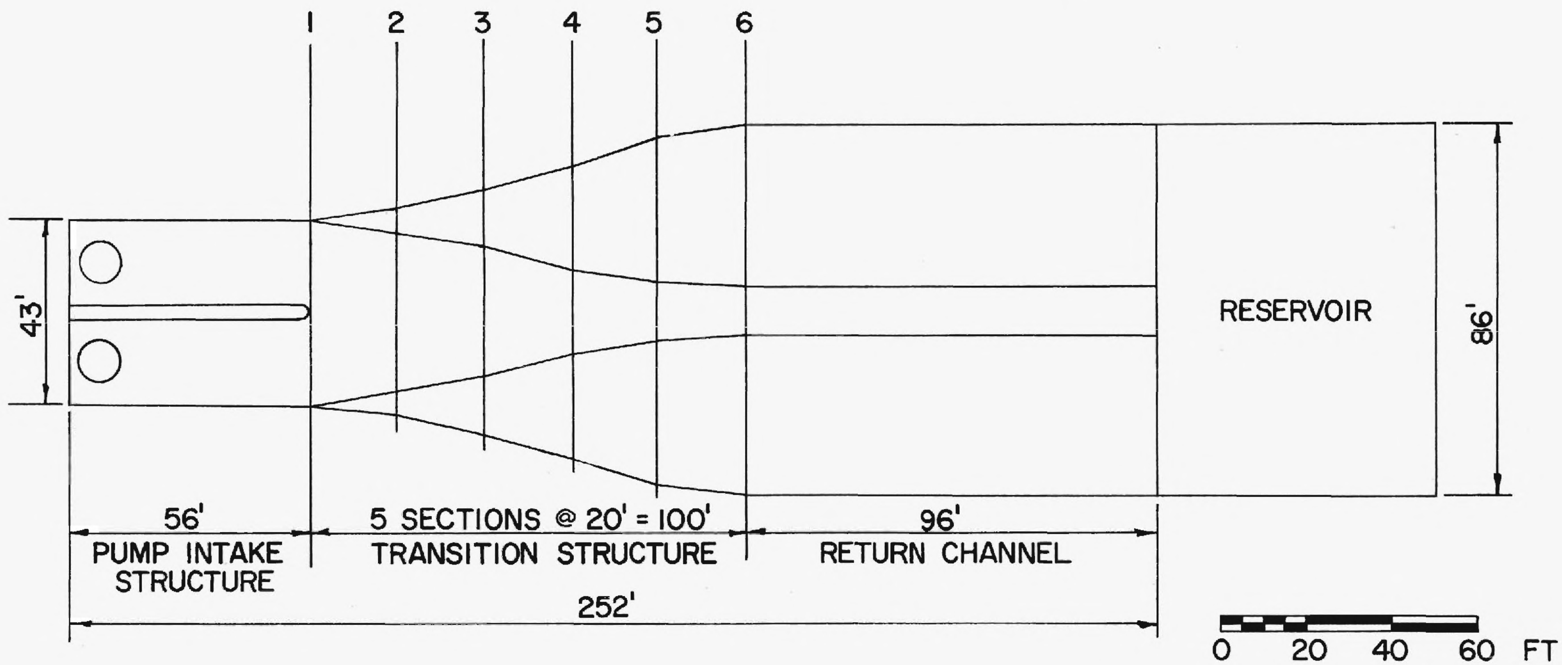


Figure A5. Plant Vogtle Model II.
Plan View.

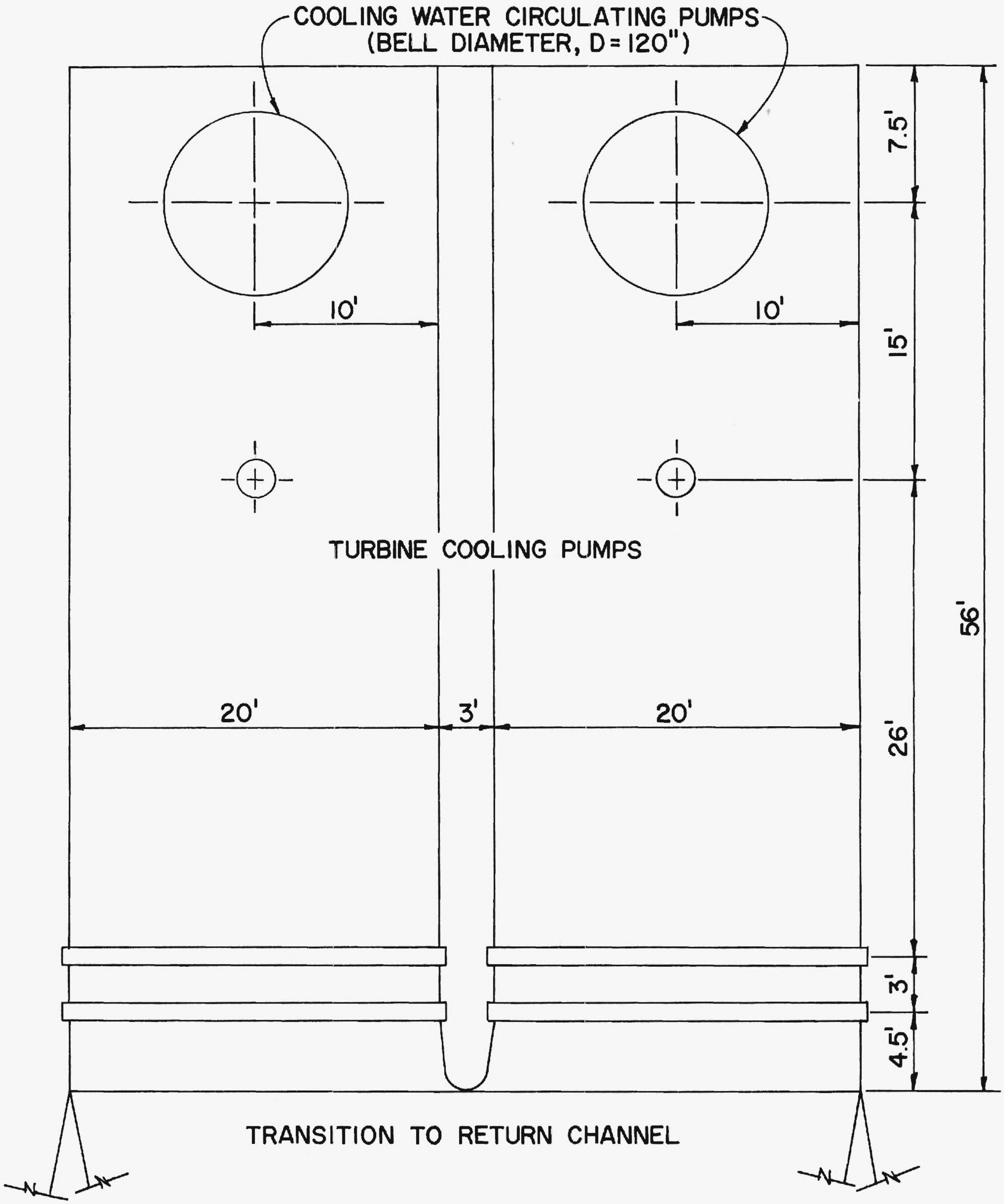


Figure A6. Vogtle II 1:8 Model.
Plan of Intake Structure.

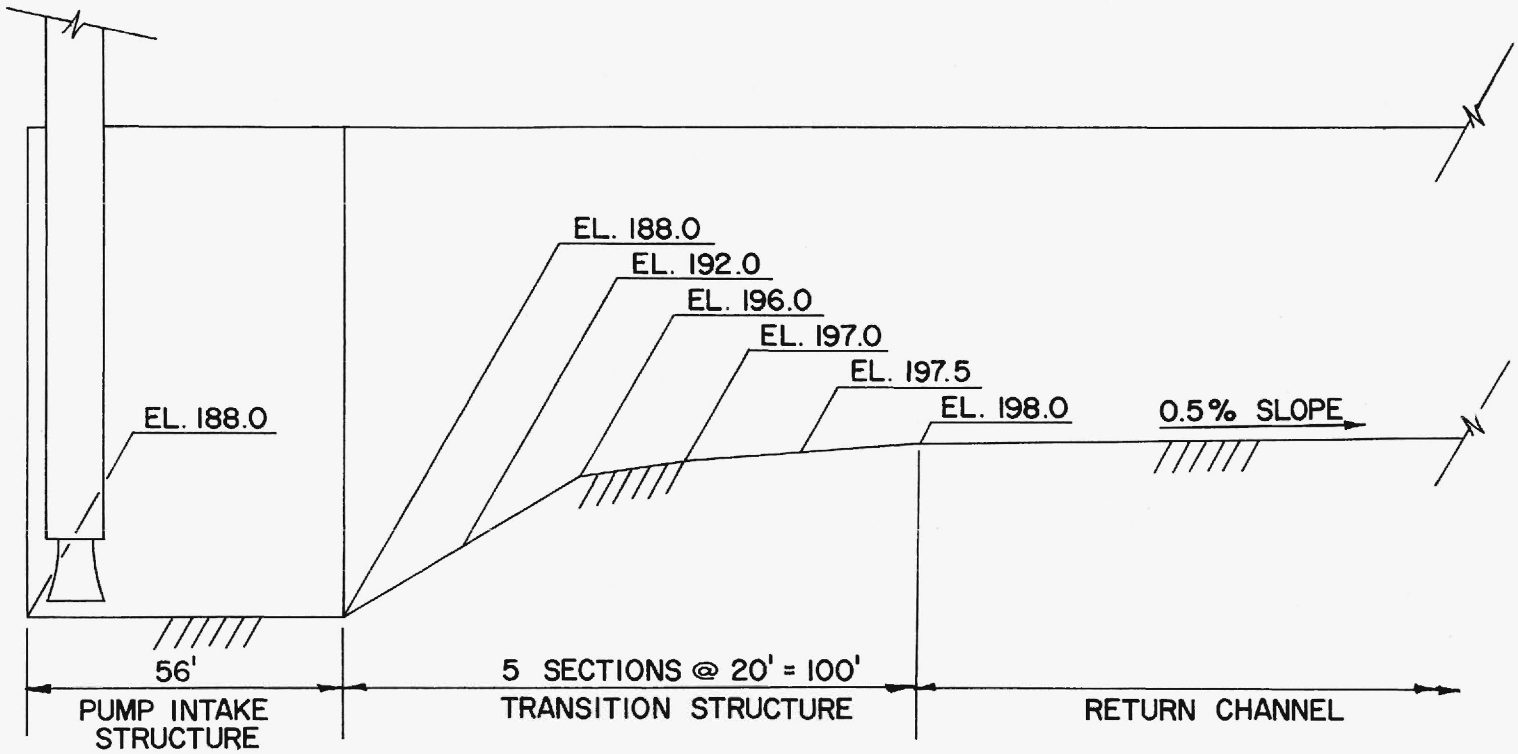


Figure A7. Vogtle II 1:8 Model.
Elevation View.

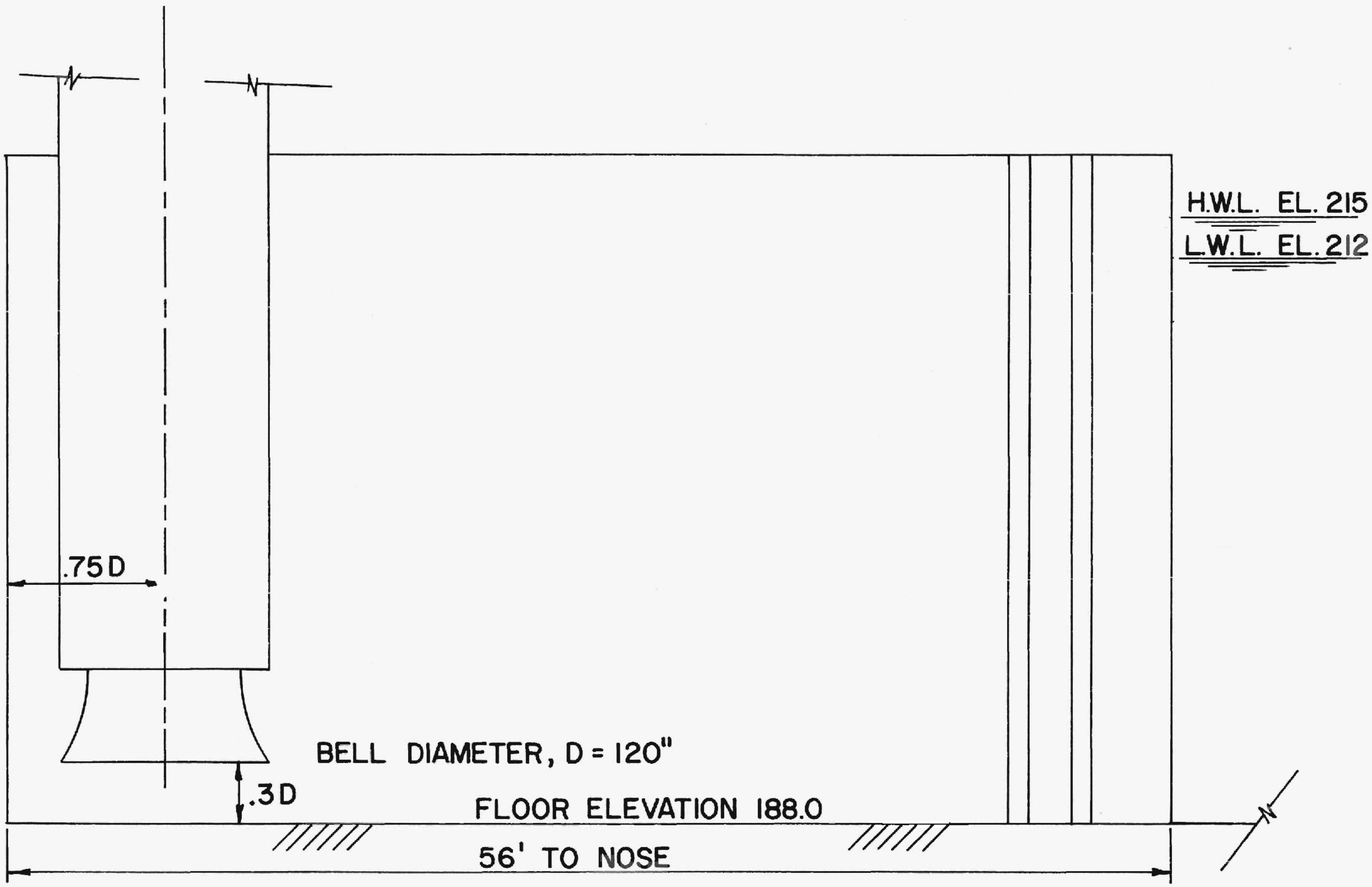


Figure A8. Vogtle II 1:8 Model.
Elevation of Pump Intake Structure.

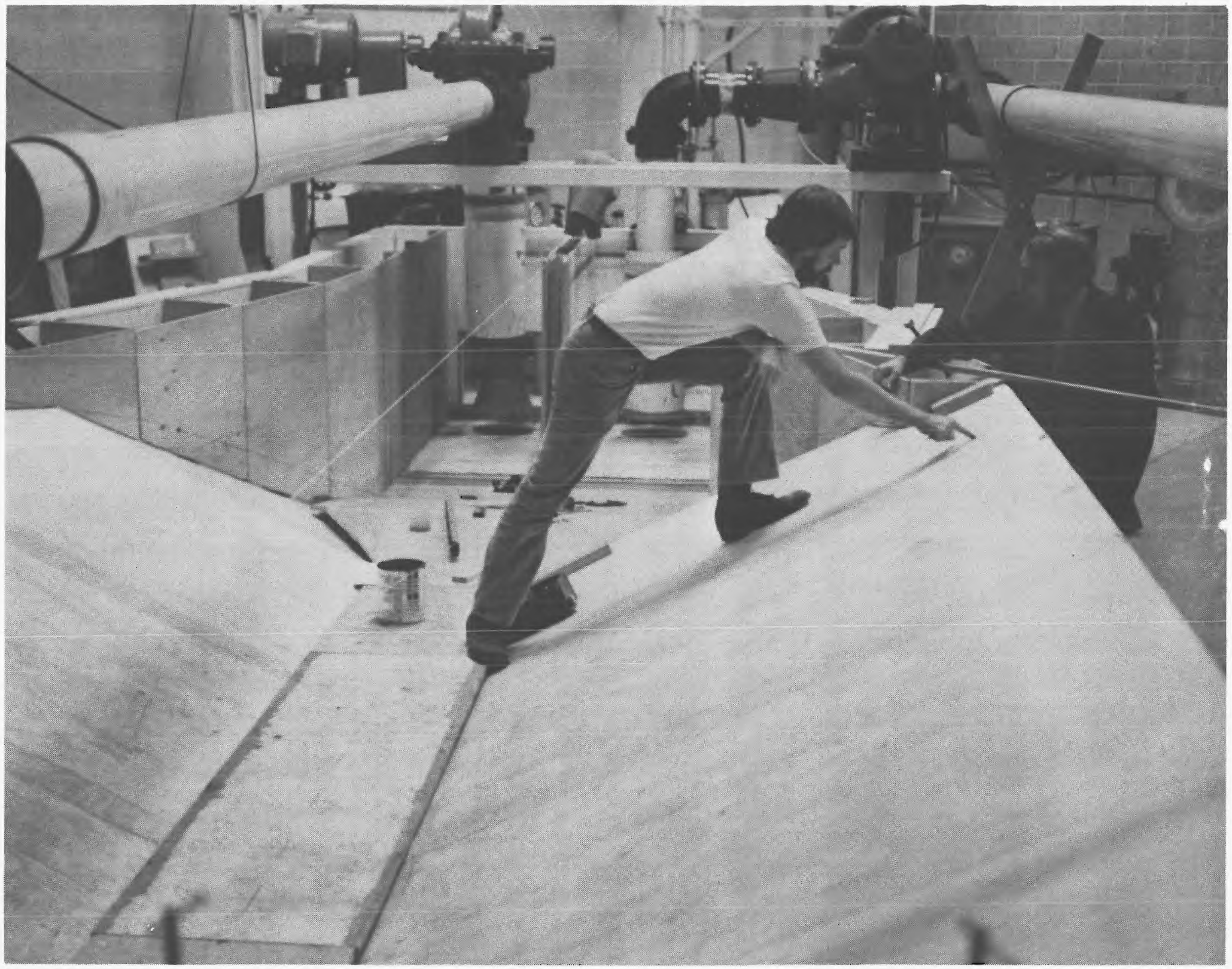


Figure A9. Vogtle II 1:8 Model.
View in Laboratory.

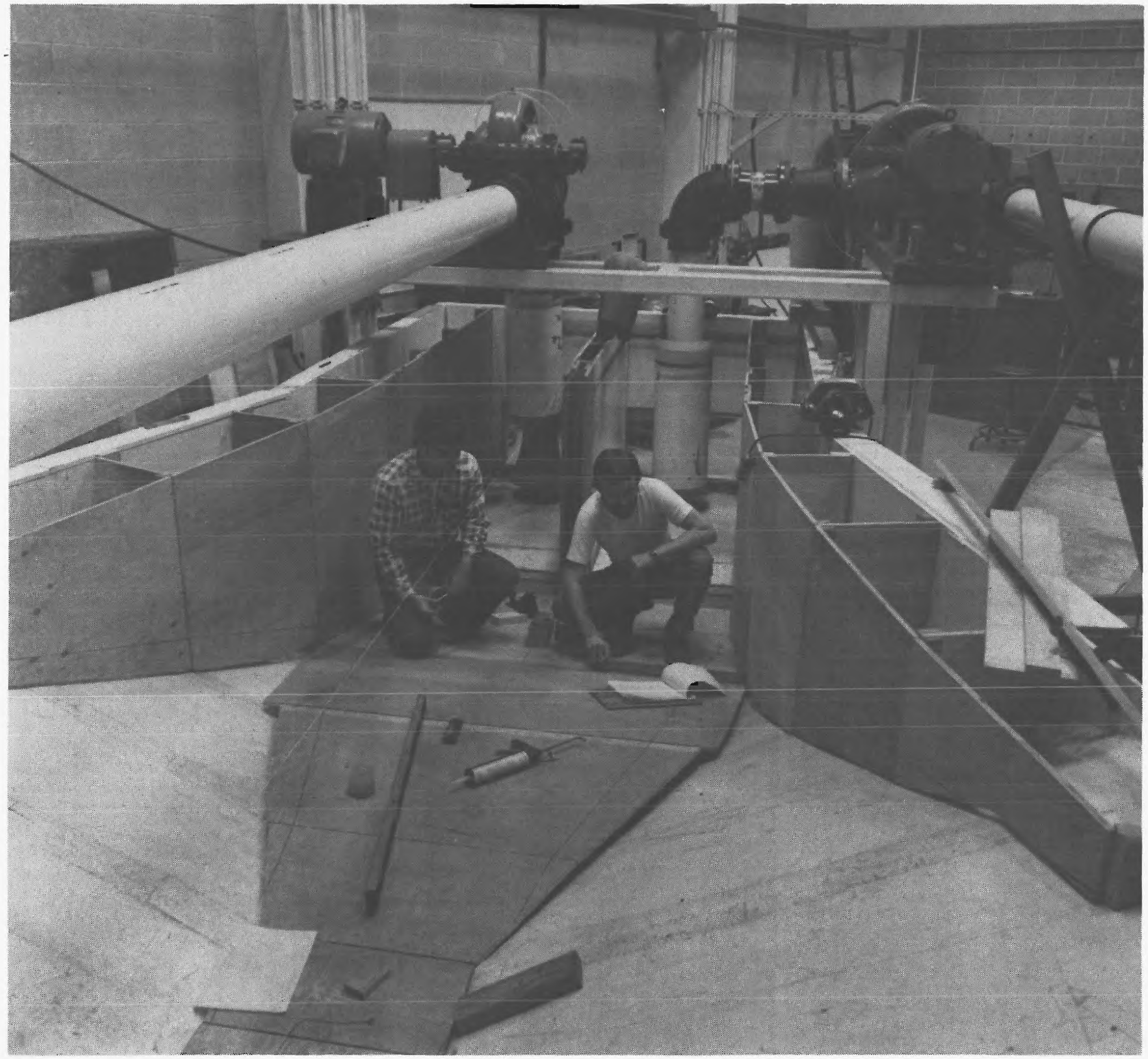


Figure A10. Vogtle II 1:8 Model.
Channel Transition Under Construction.

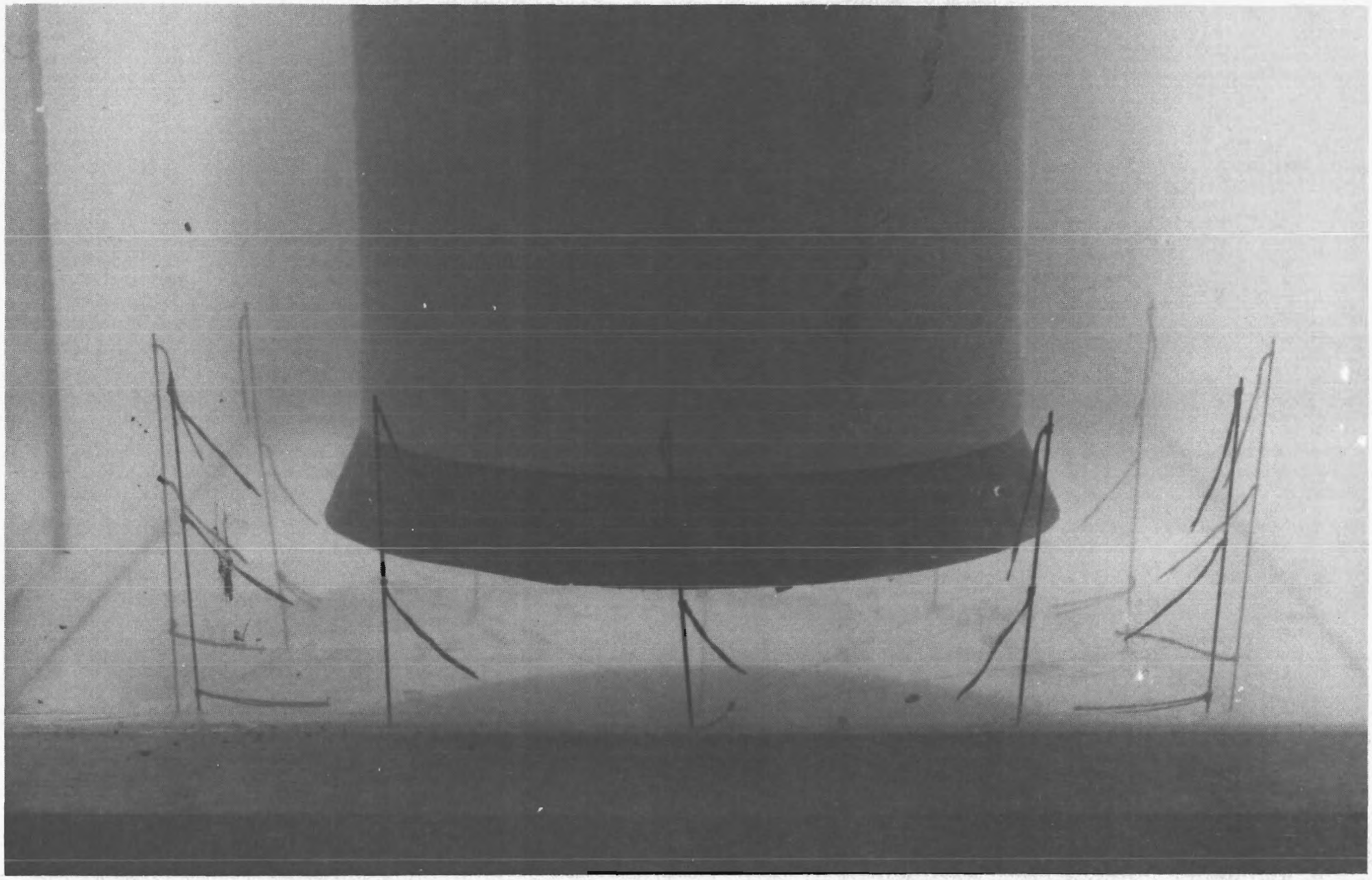


Figure A11. Vogtle II 1:8 Model.
Close-Up of Suction Bell in Operation.

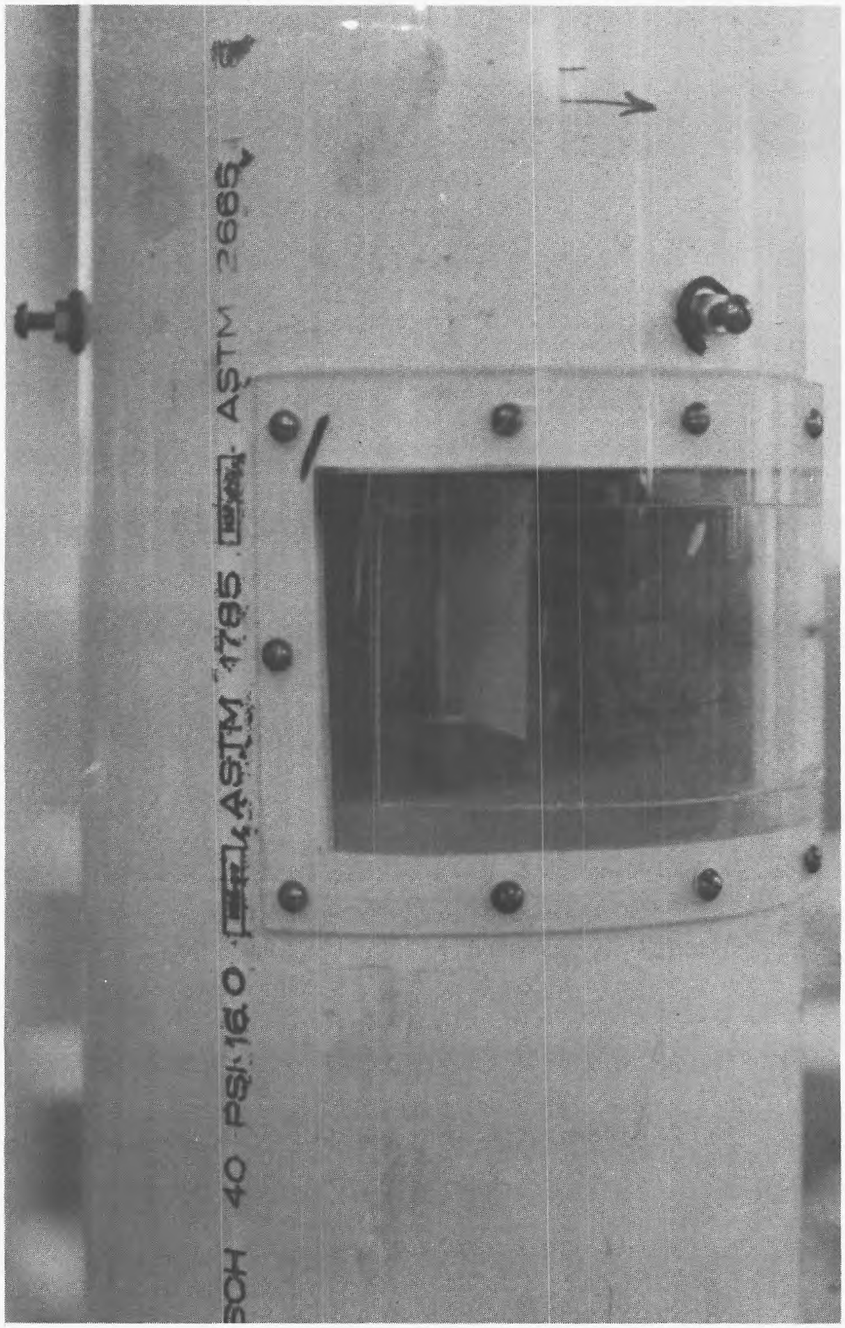


Figure A12. Vogtle II 1:8 Model.
Close-Up of Vortimeter in Suction Line.

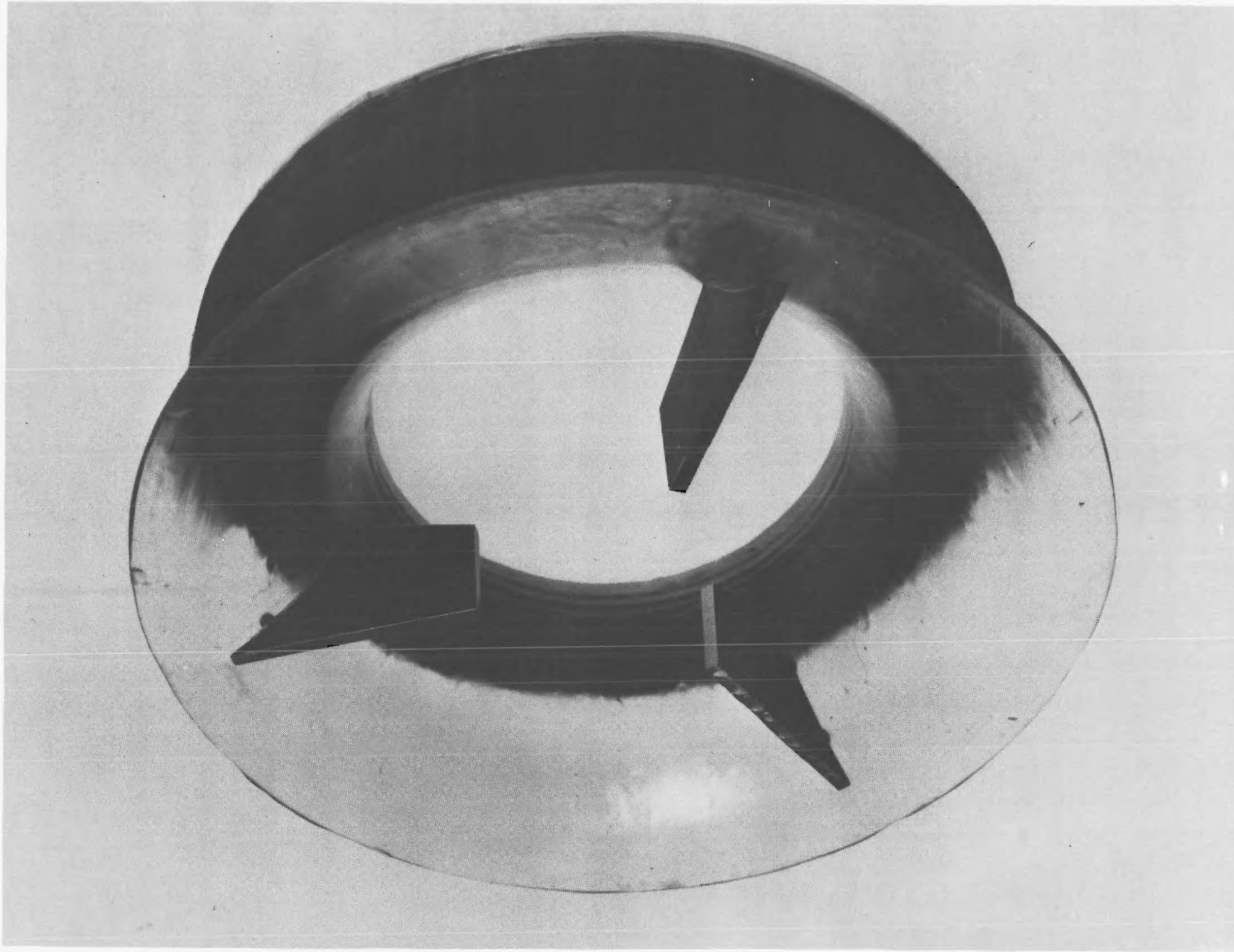


Figure A13. Typical Cast Suction Bell.

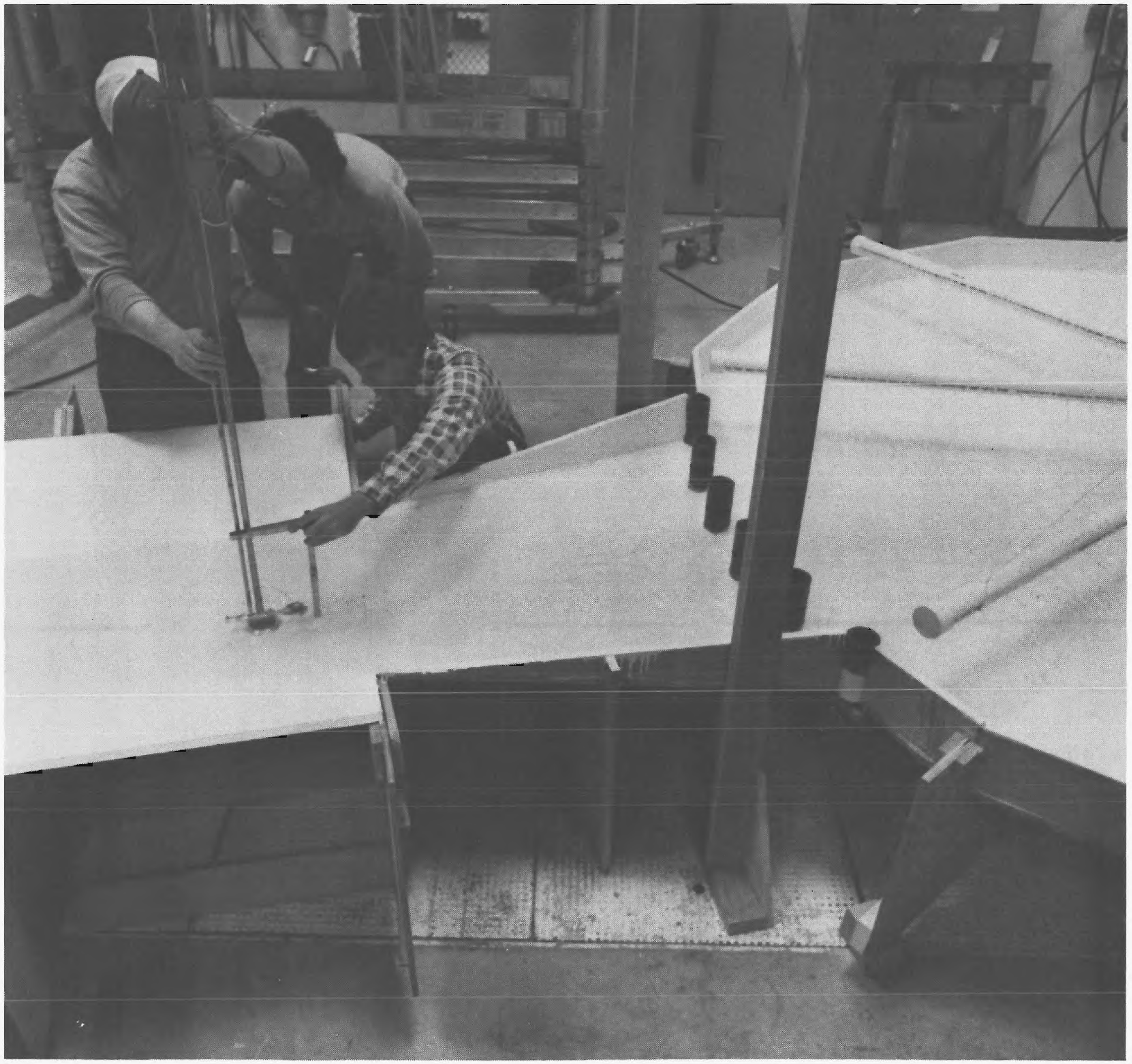


Figure A14. Vogtle II 1:40 Model.
Typical Flow Measurement.

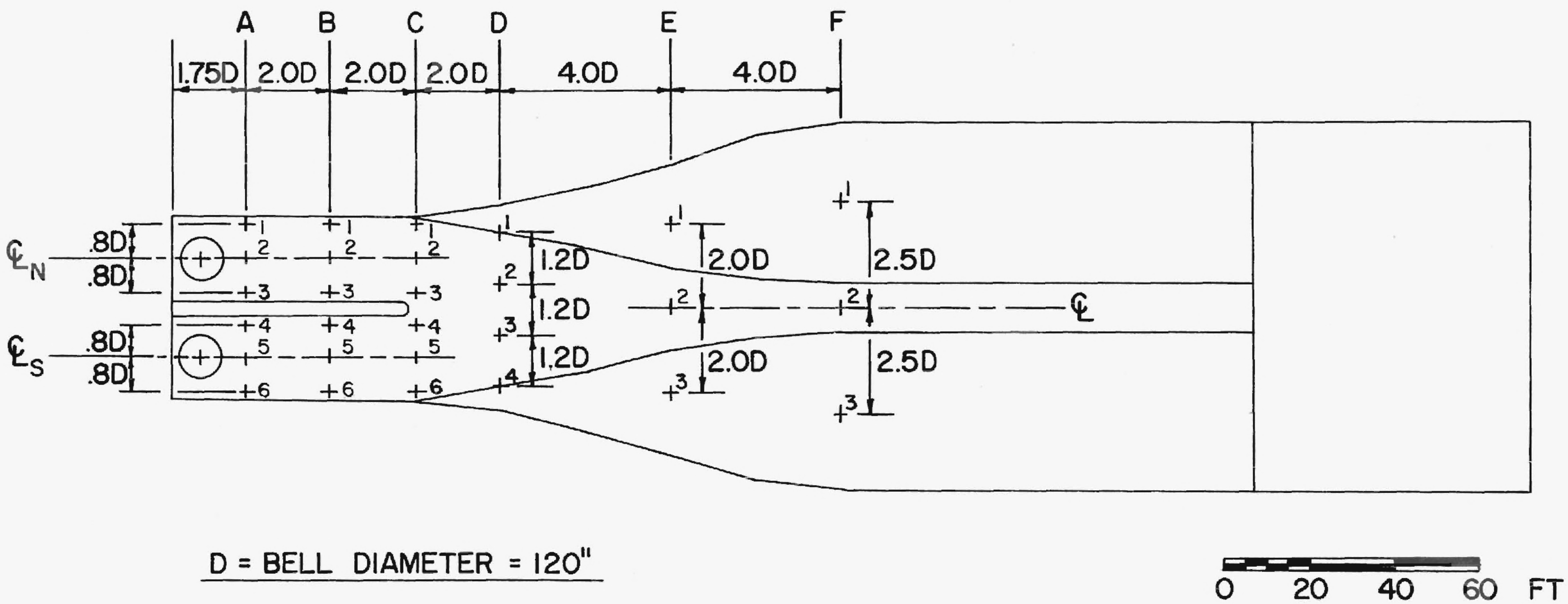


Figure A15. Vogtle II, Velocity Measuring Stations.

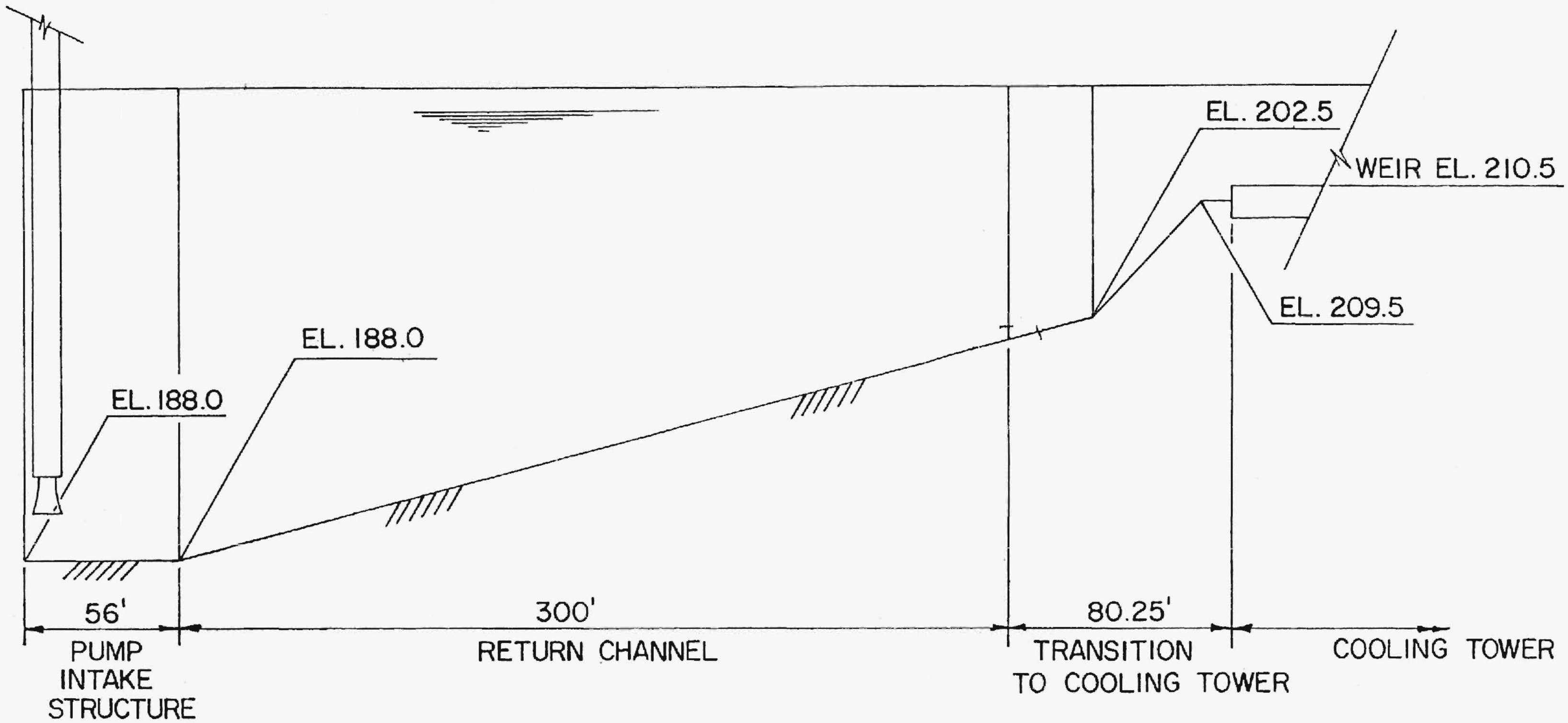


Figure A16. Vogtle III, Longitudinal Profile.

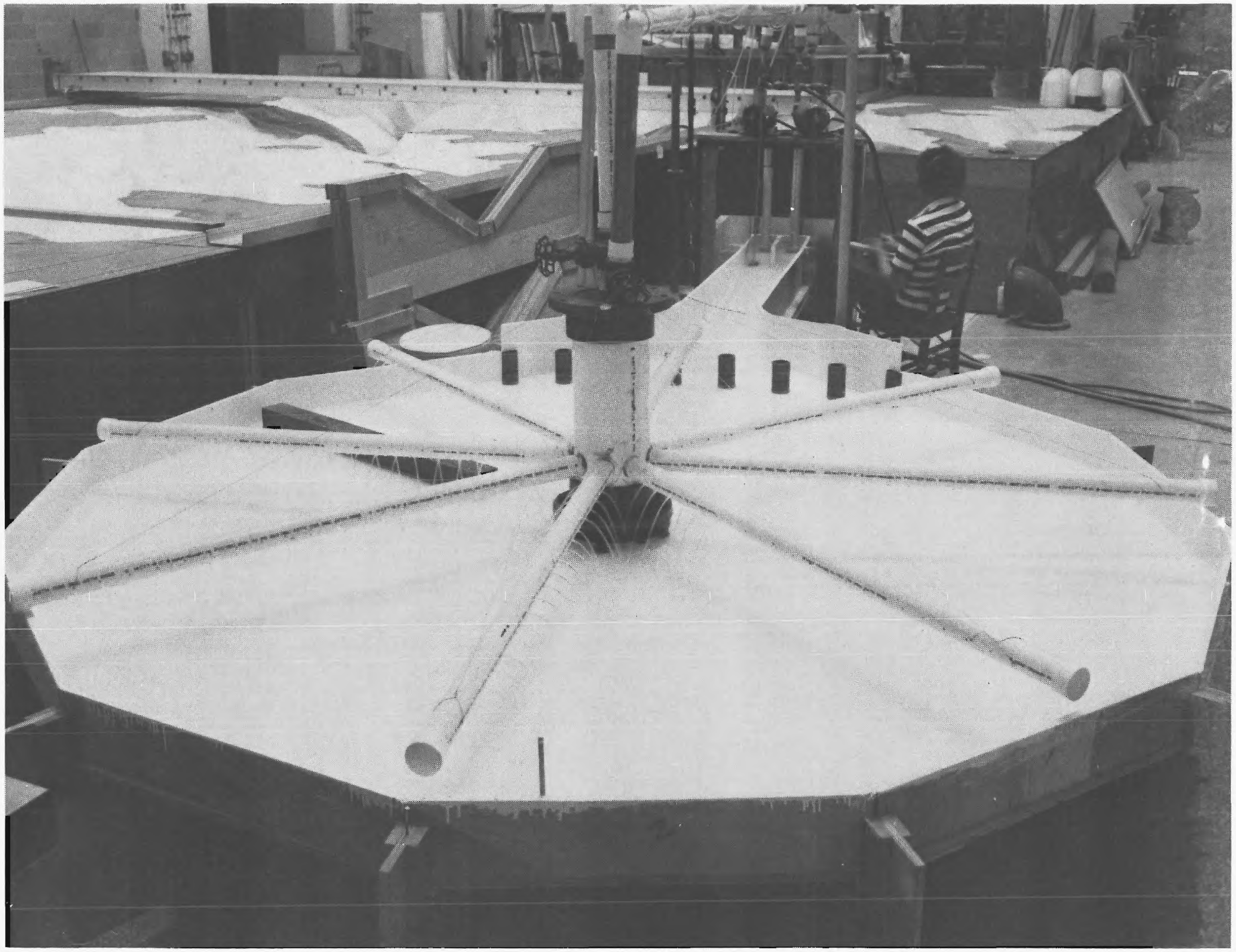


Figure A17. Vogtle III 1:40 Model,
Model in Operation.

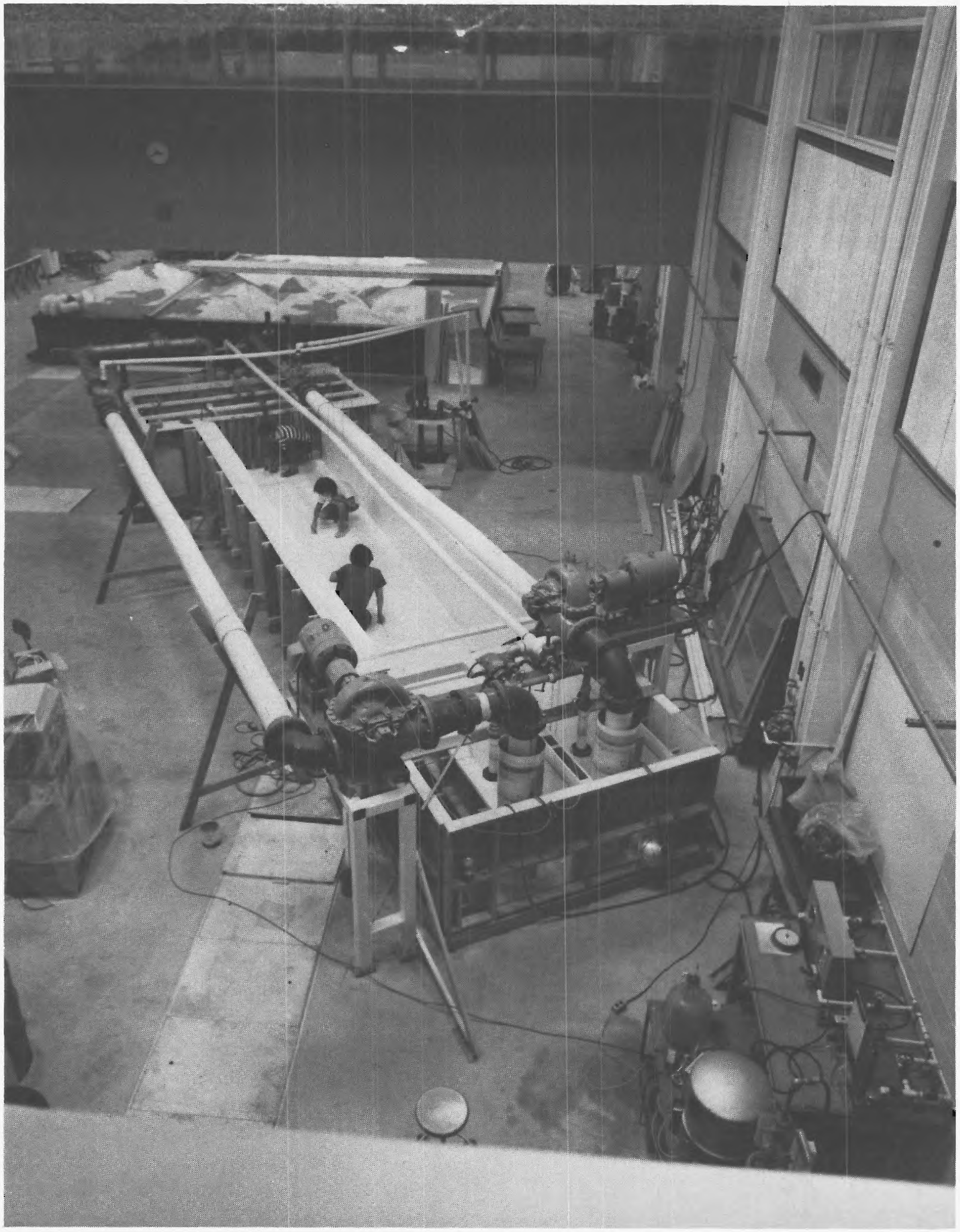


Figure A18. Vogtle III 1:8 Model,
Model in Laboratory.

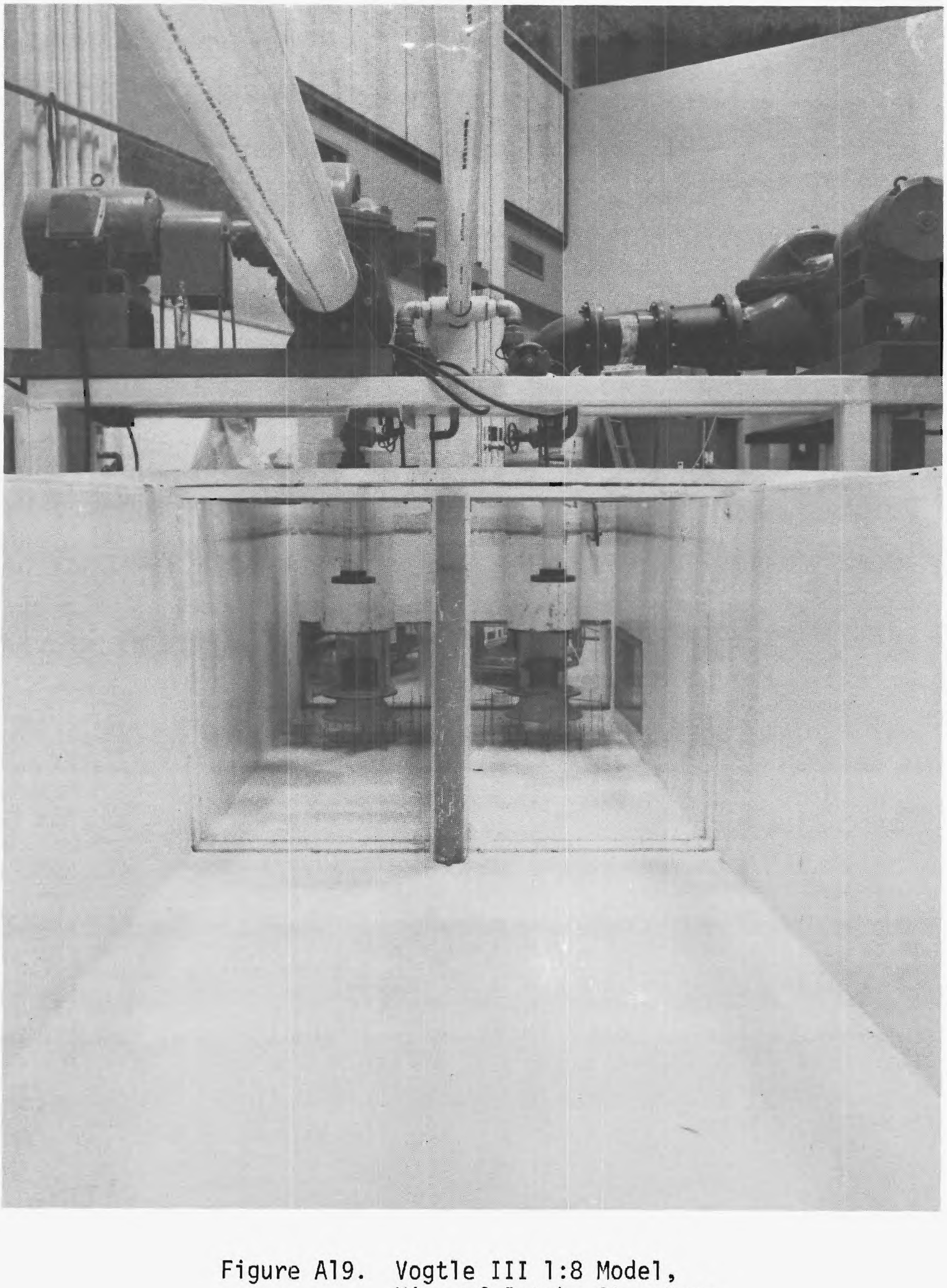


Figure A19. Vogtle III 1:8 Model,
View of Intake Structure.

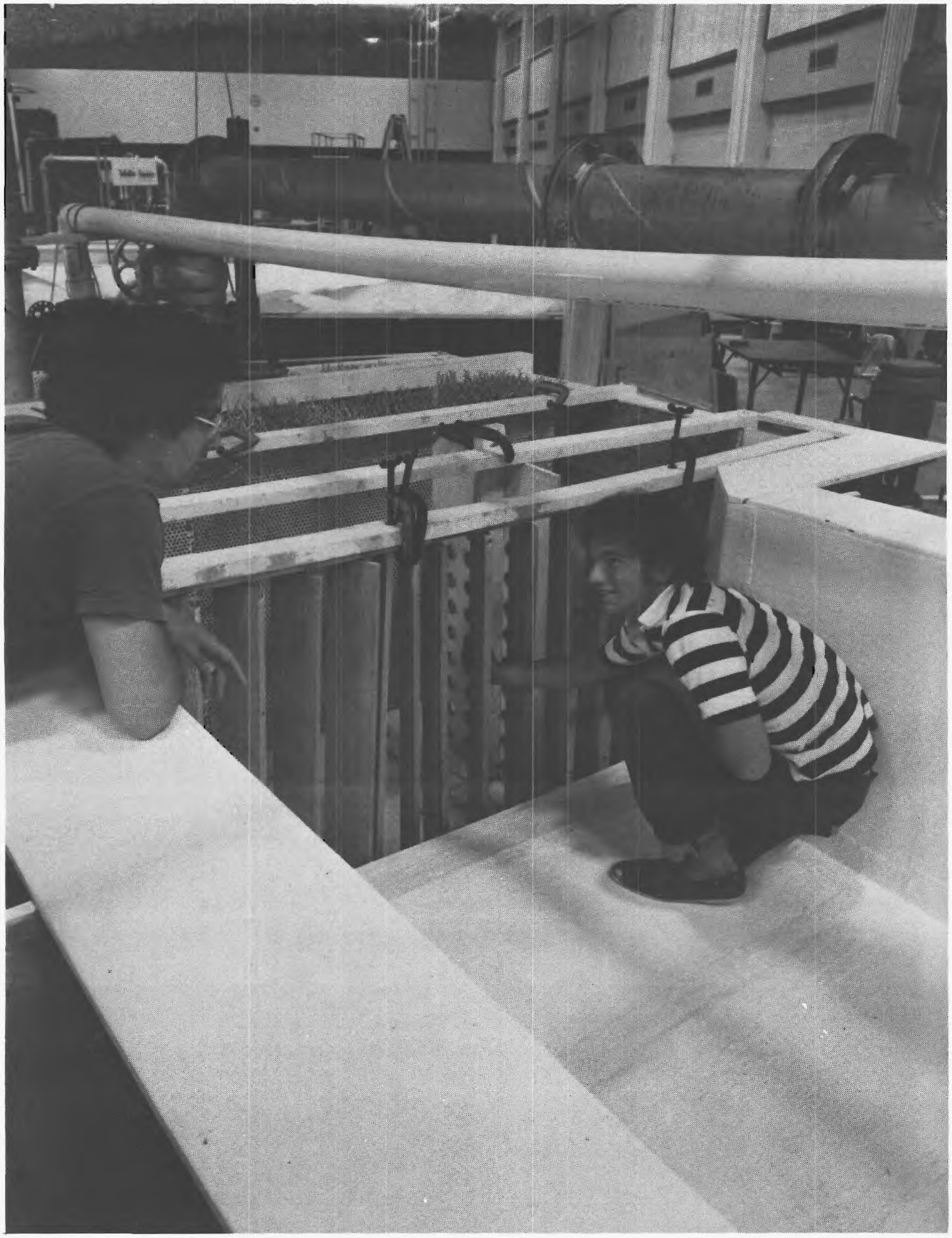


Figure A20. Vogtle III 1:8 Model,
View of Baffles at Head Bay.

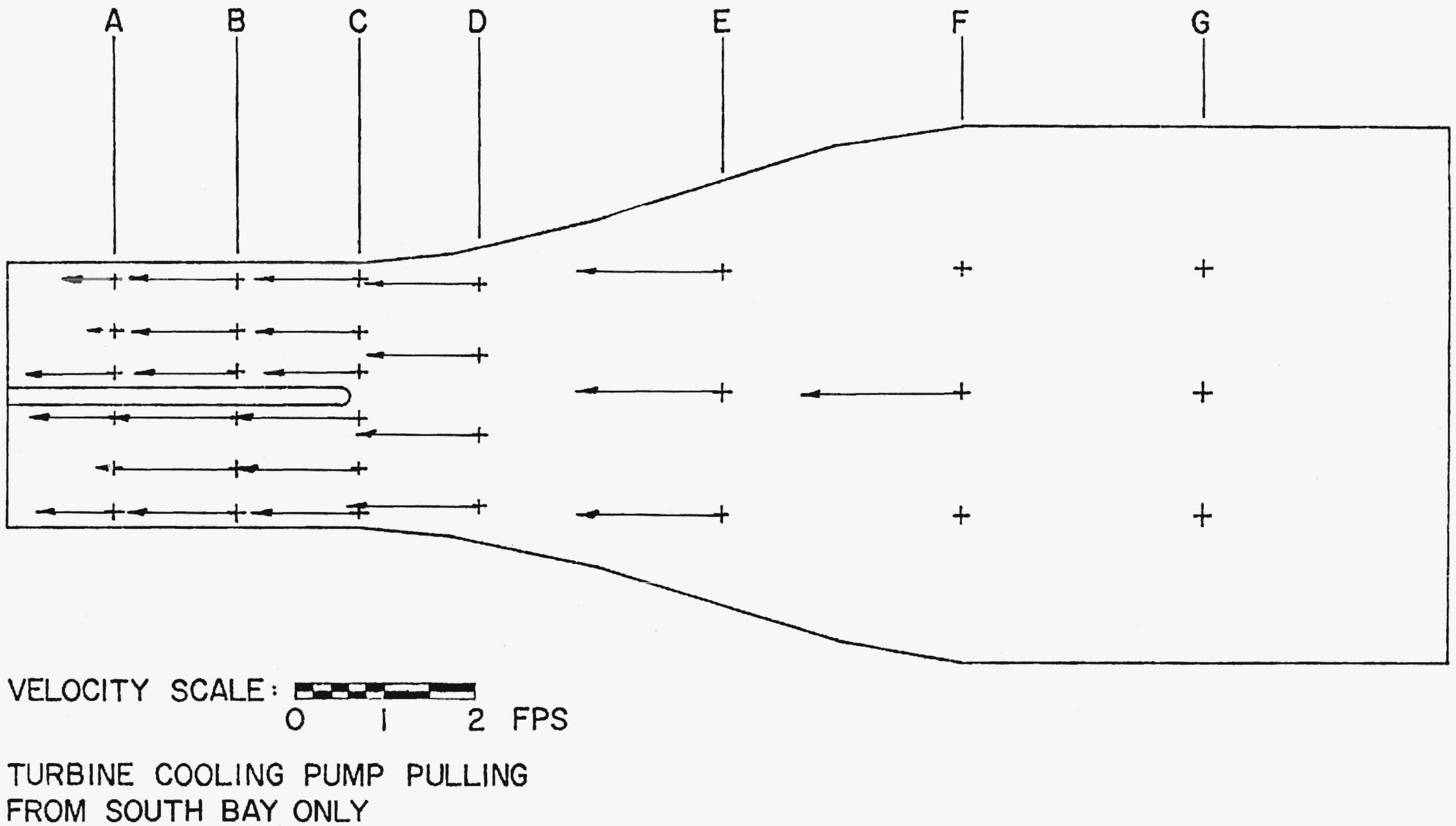
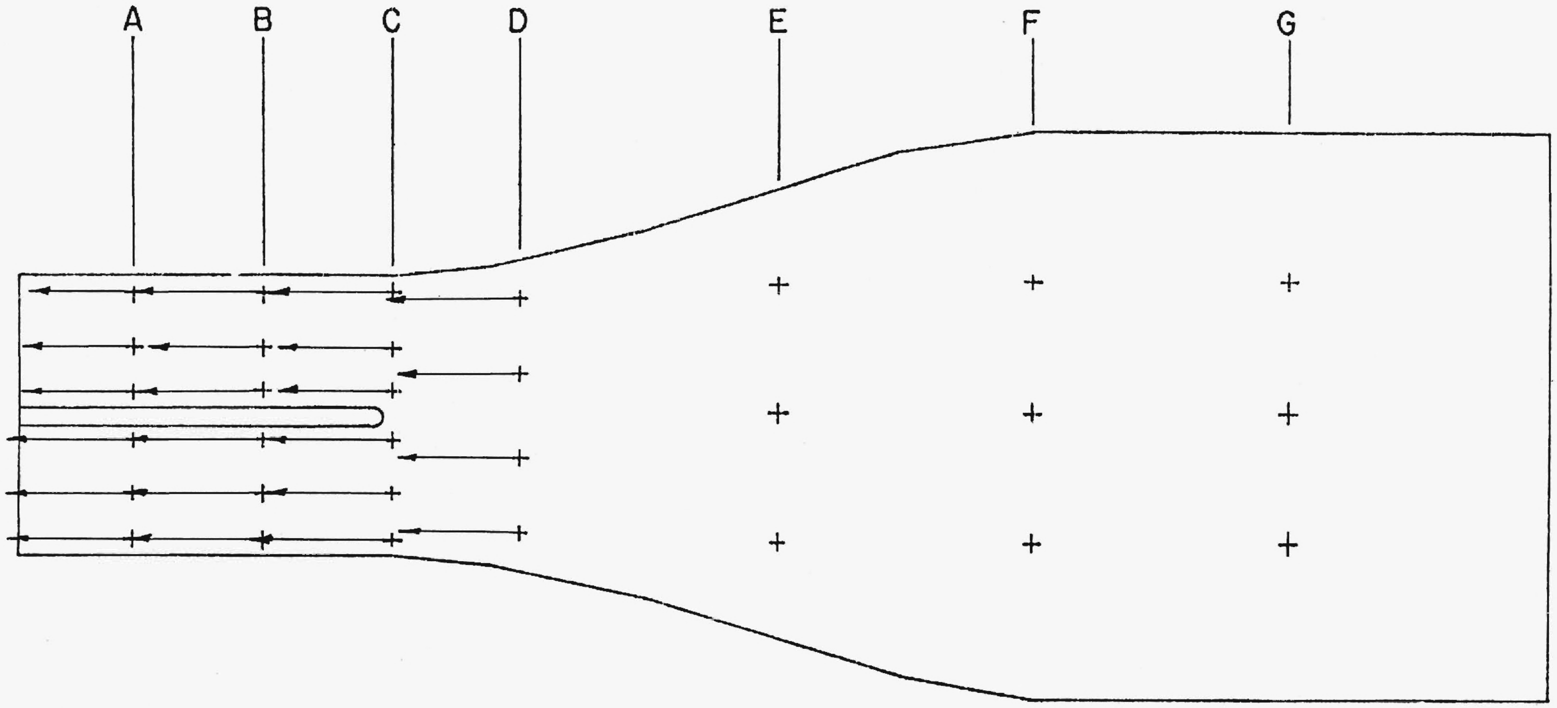


Figure A21. Vogtle II 1:8 Model, Velocity Vectors 2' Below Water Surface. Q = 600 CFS in Both Pumps.



VELOCITY SCALE:
0 1 2 FPS

TURBINE COOLING PUMP PULLING
FROM SOUTH BAY ONLY

Figure A22. Vogtle II 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in Both Pumps.

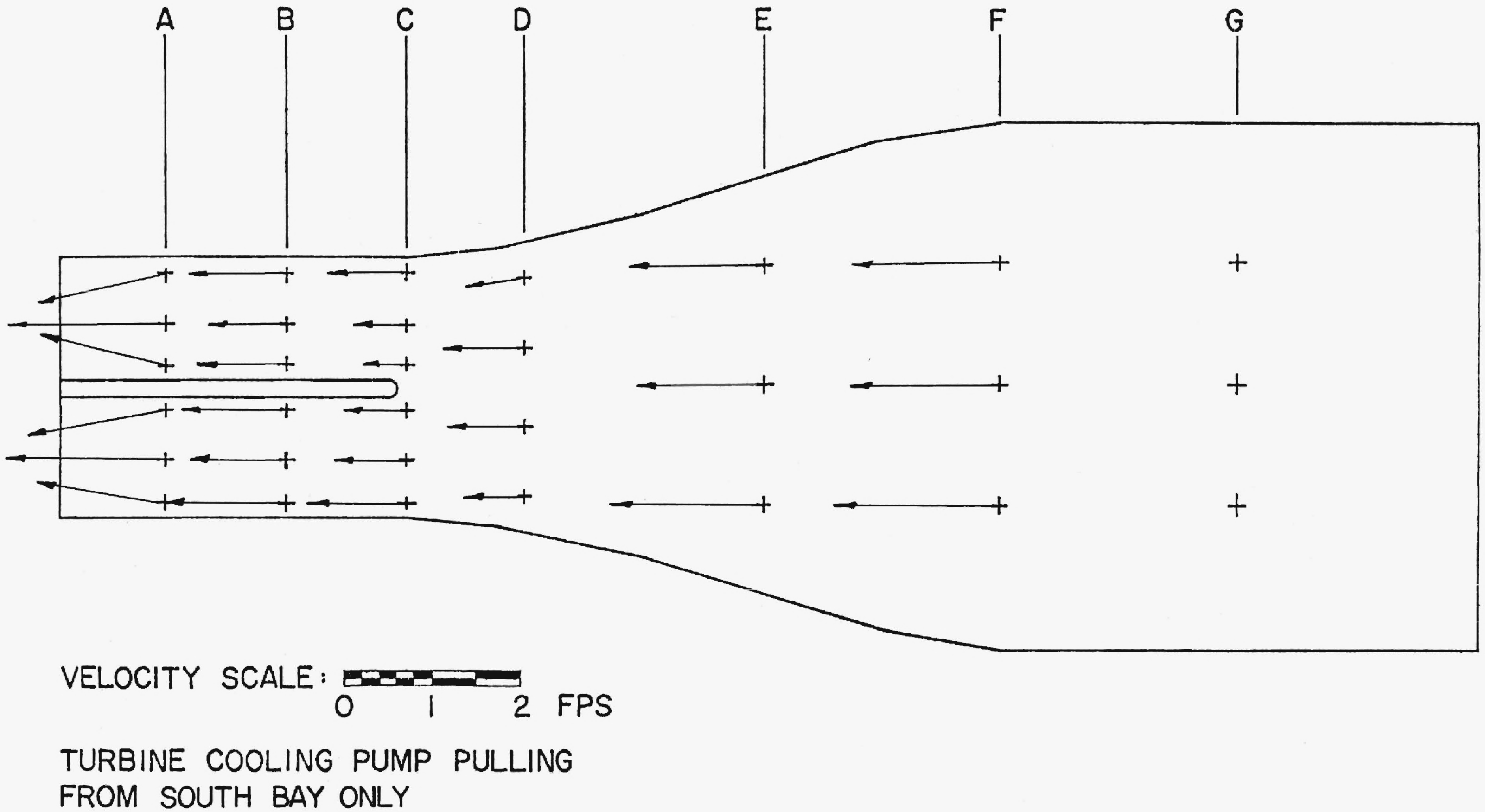


Figure A23. Vogtle II 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in Both Pumps.

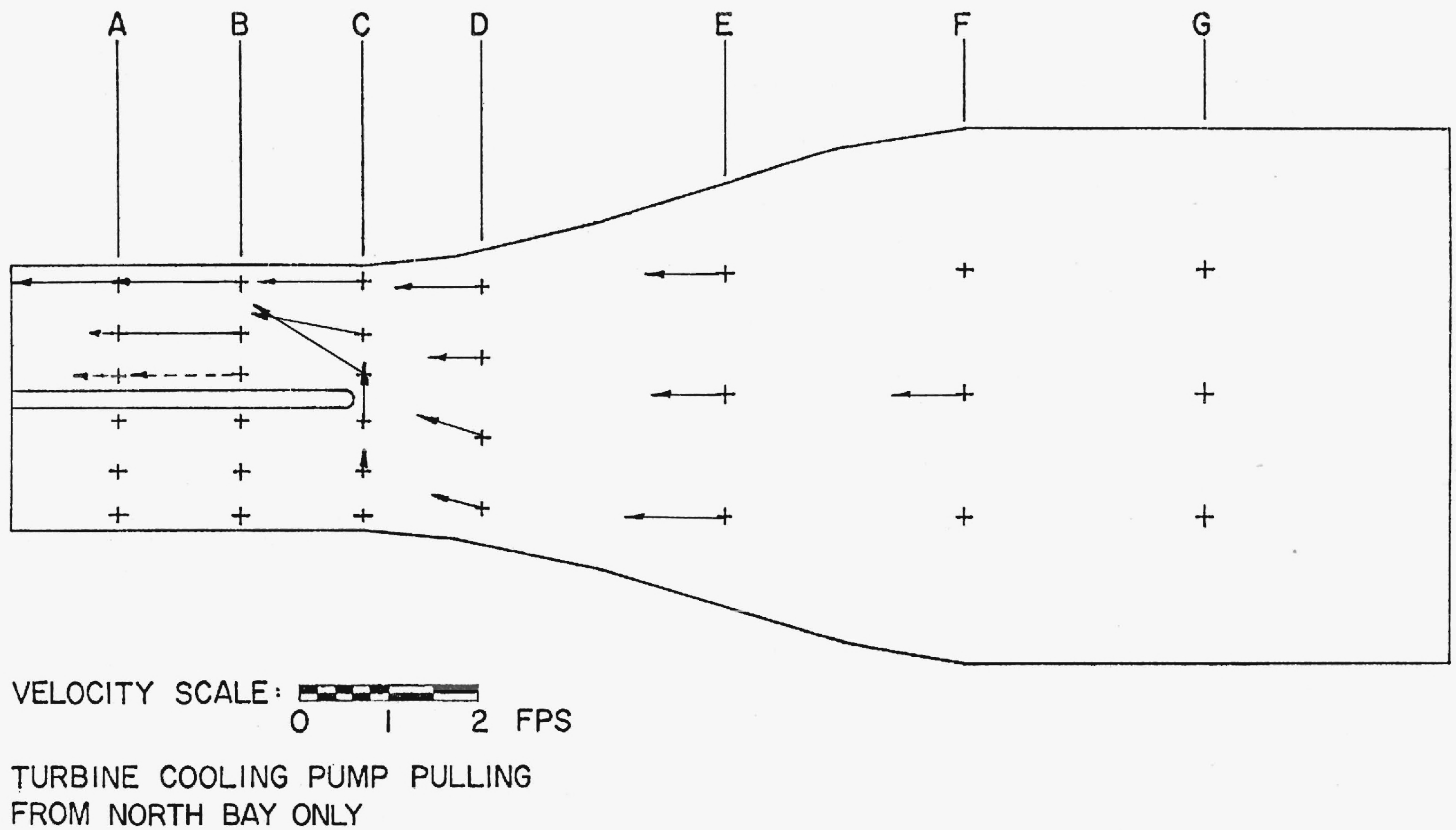


Figure A24. Vogtle II 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in North Pump Only.

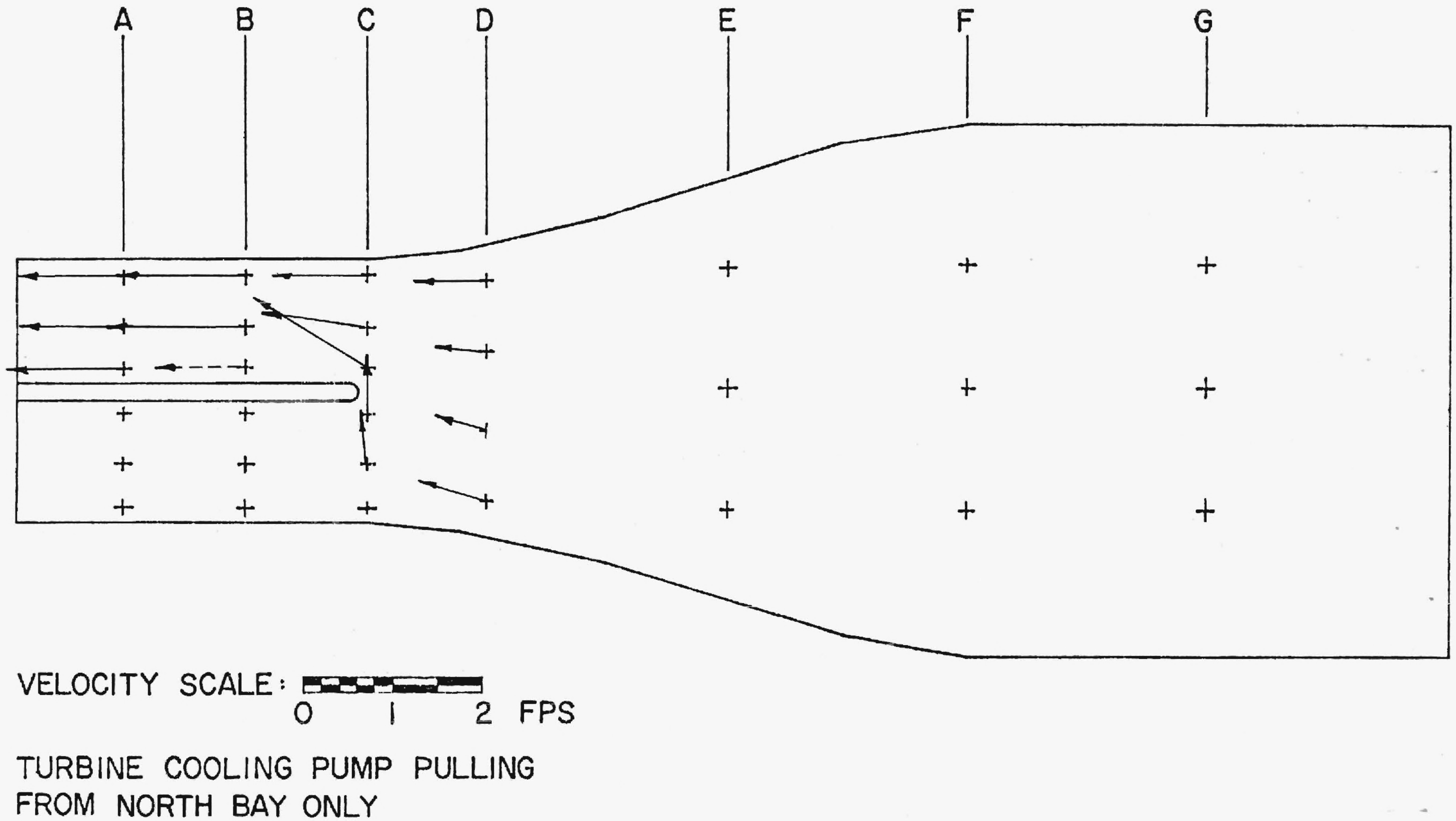
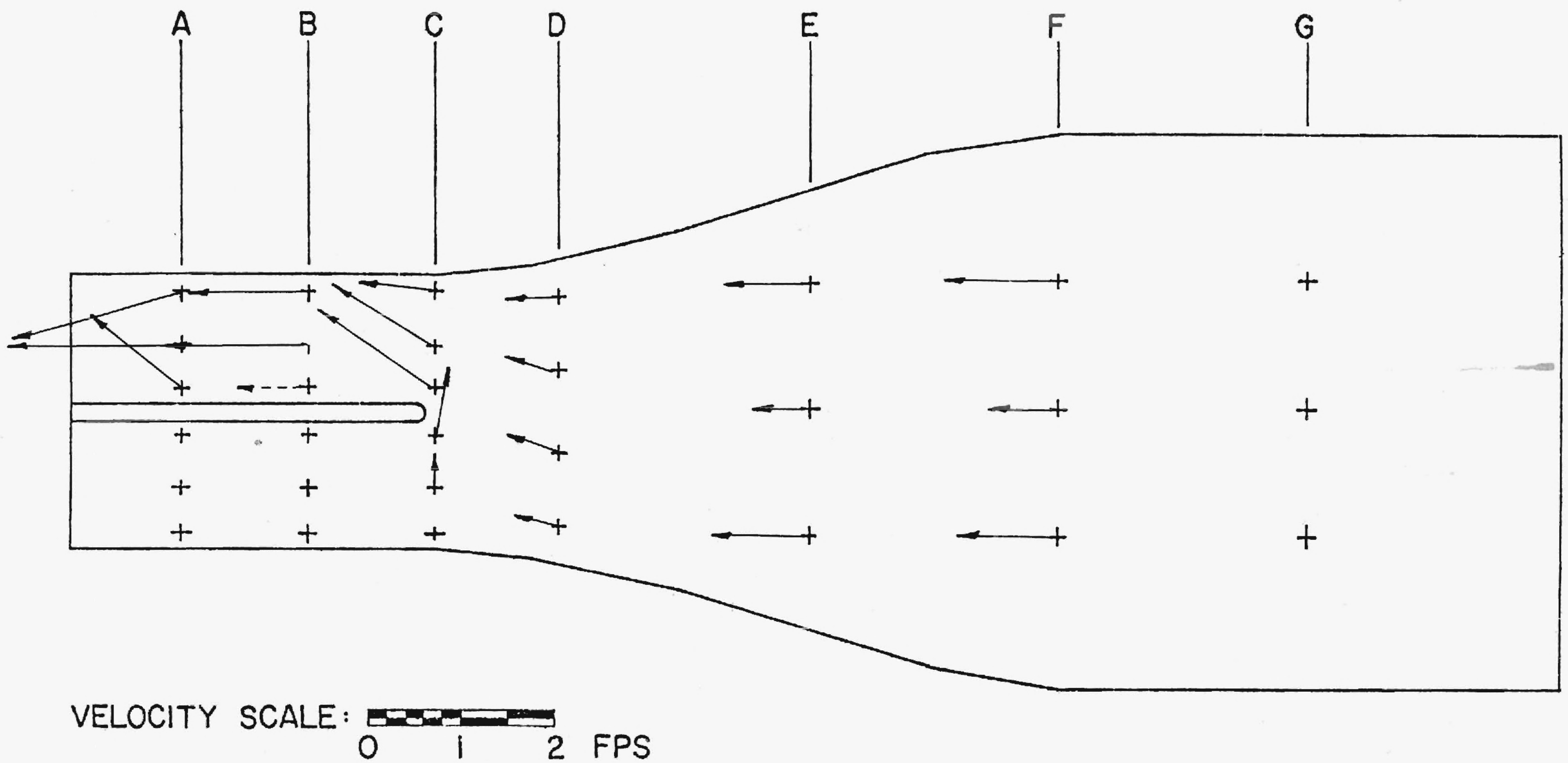


Figure A25. Vogtle II 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in North Pump Only.



TURBINE COOLING PUMP PULLING
FROM NORTH BAY ONLY

Figure A26. Vogtle II 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in North Pump Only.

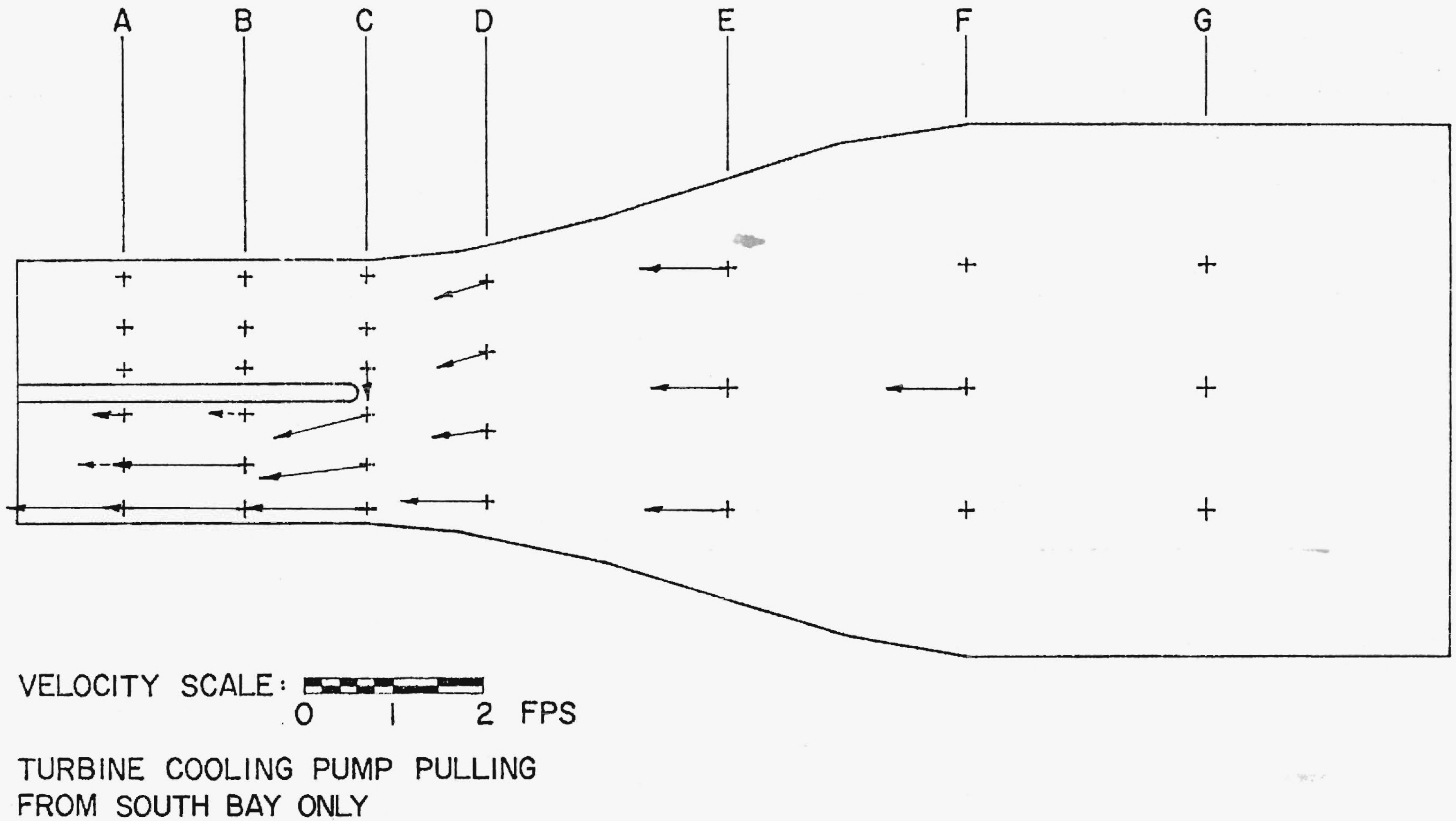


Figure A27. Vogtle II 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in South Pump Only.

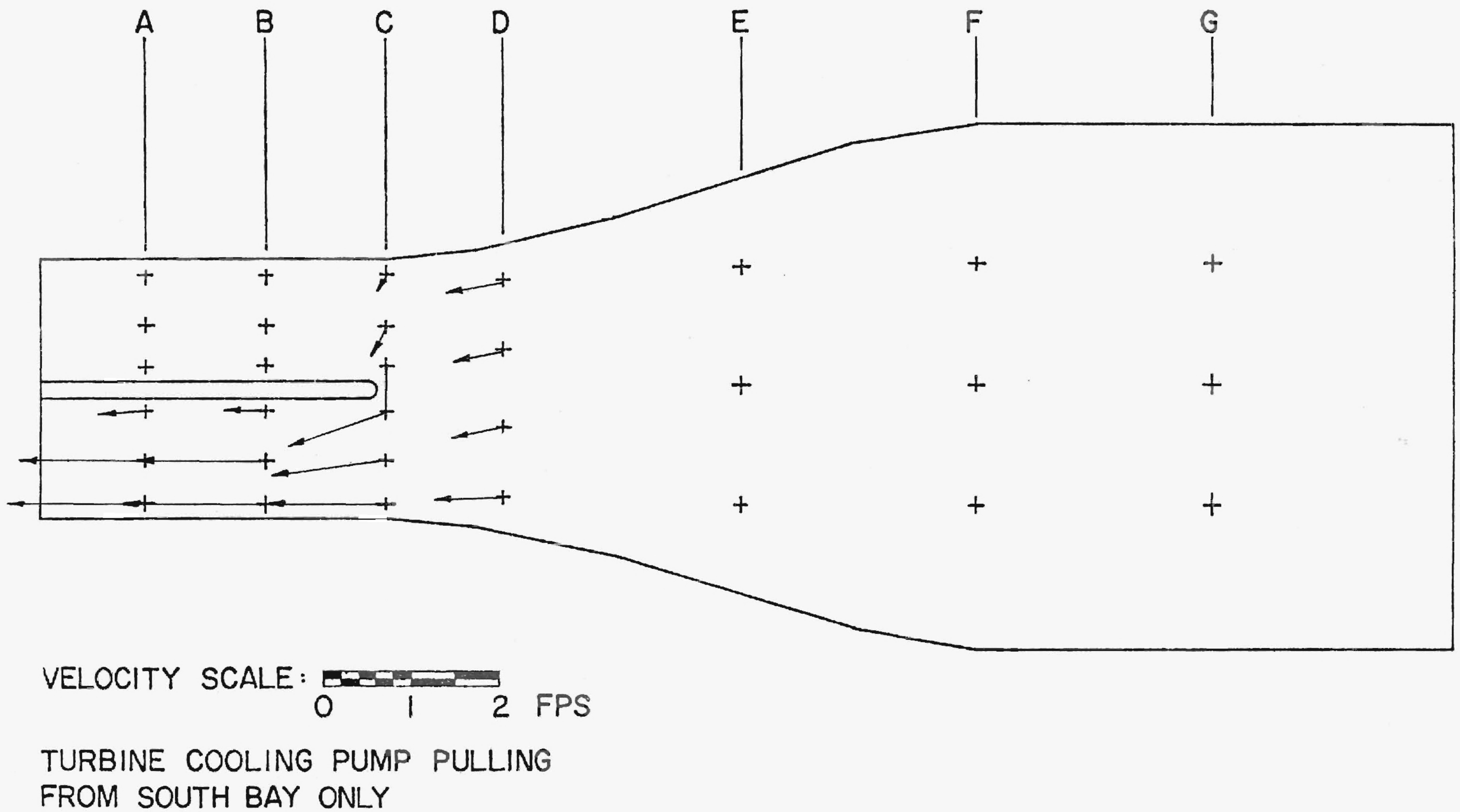


Figure A28. Vogtle II 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in South Pump Only.

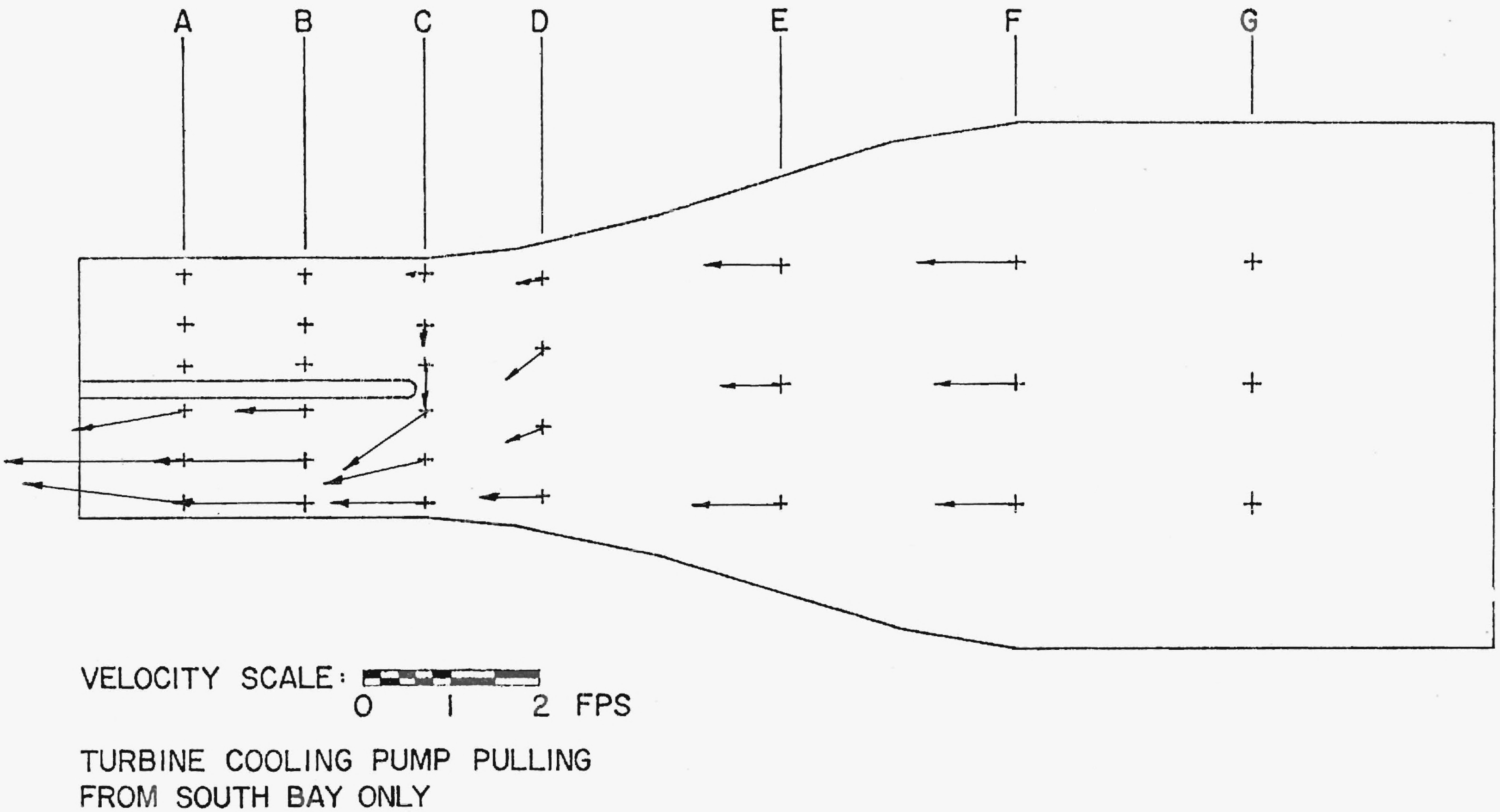


Figure A29. Vogtle II 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in South Pump Only.

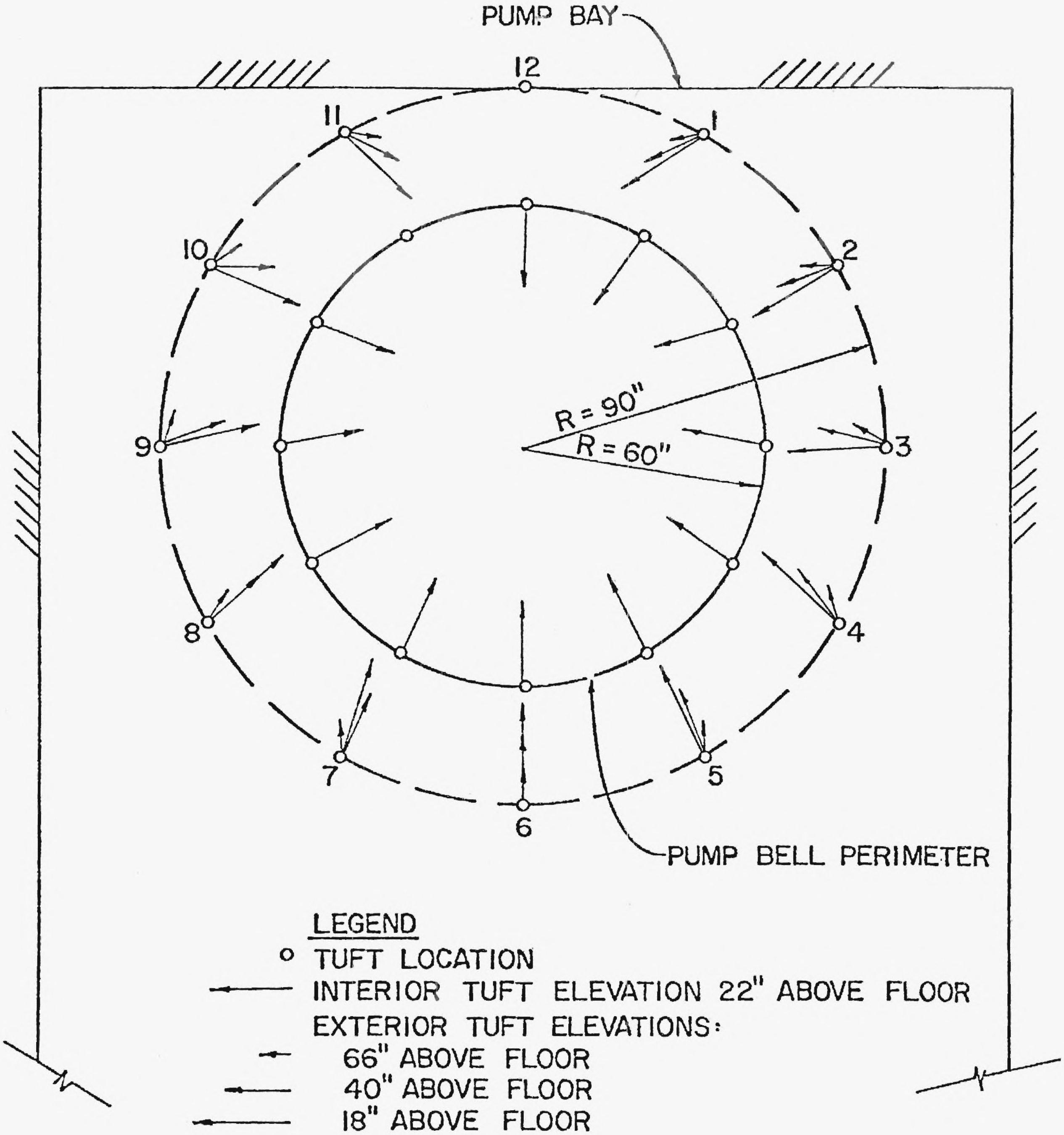


Figure A30. Vogtle II 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in Both Pumps, No Splitter Wall.

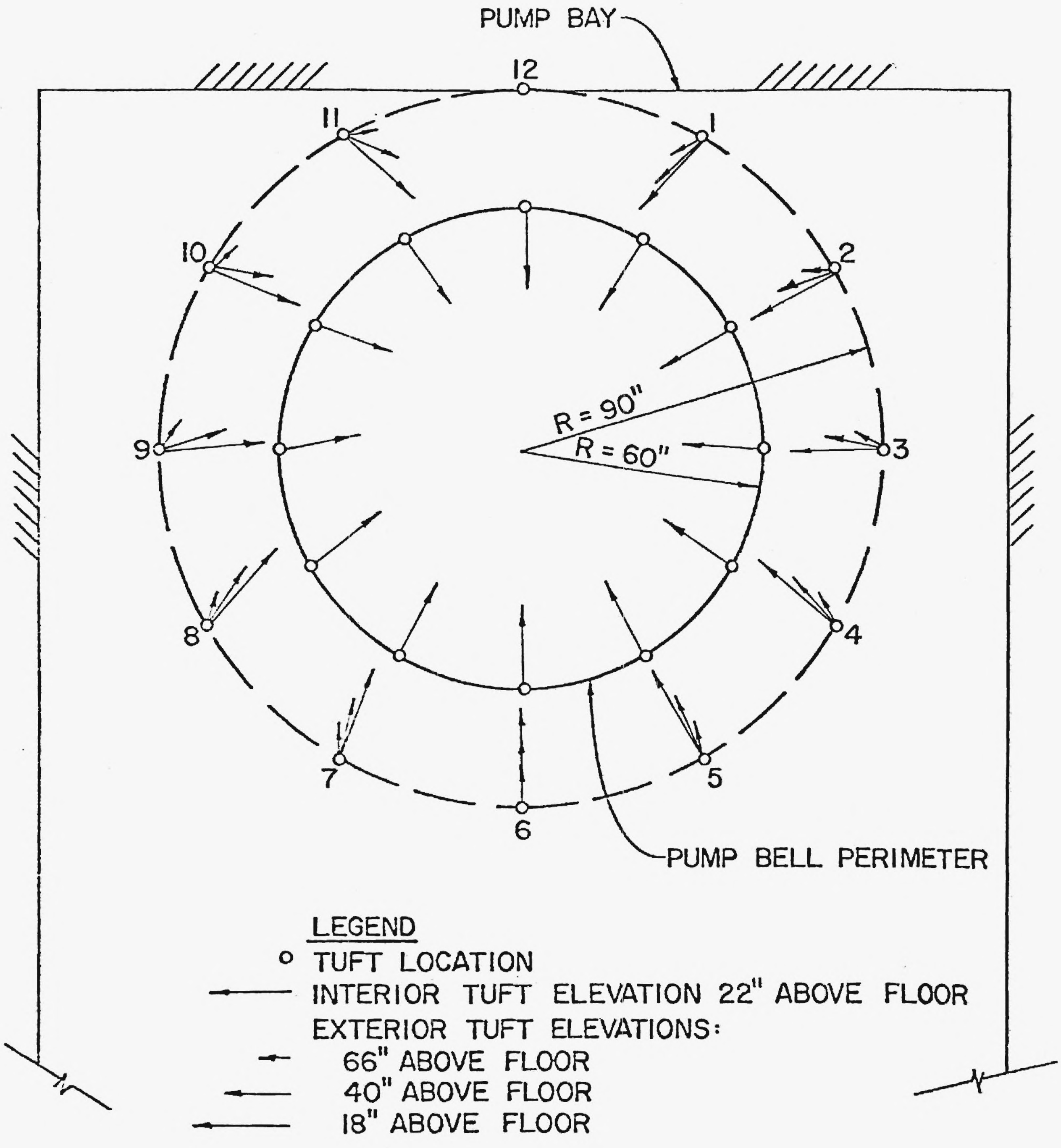


Figure A31. Vogtle II 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in Both Pumps, No Splitter Wall.

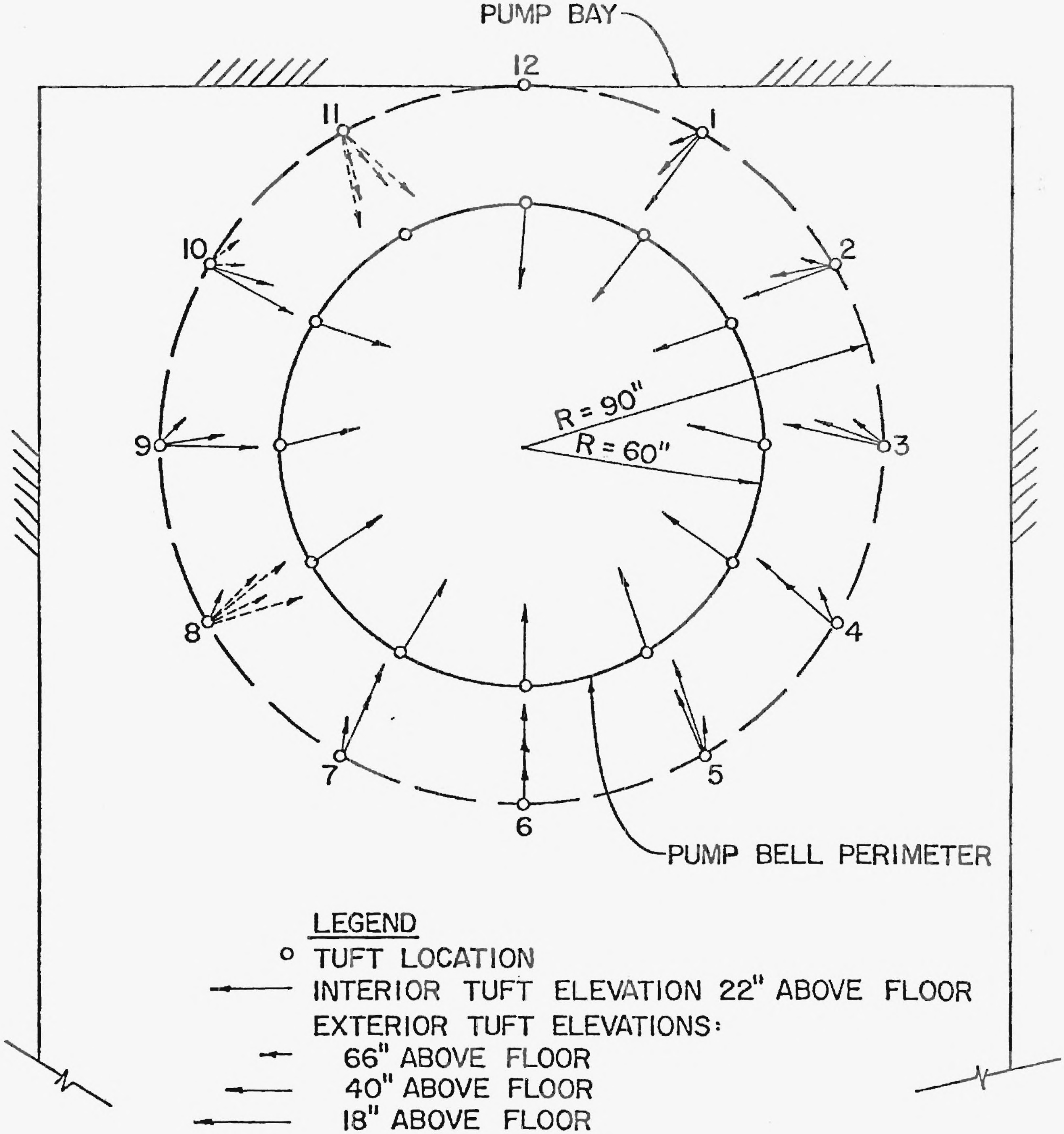


Figure A32. Vogtle II 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in North Pump Only, No Splitter Wall.

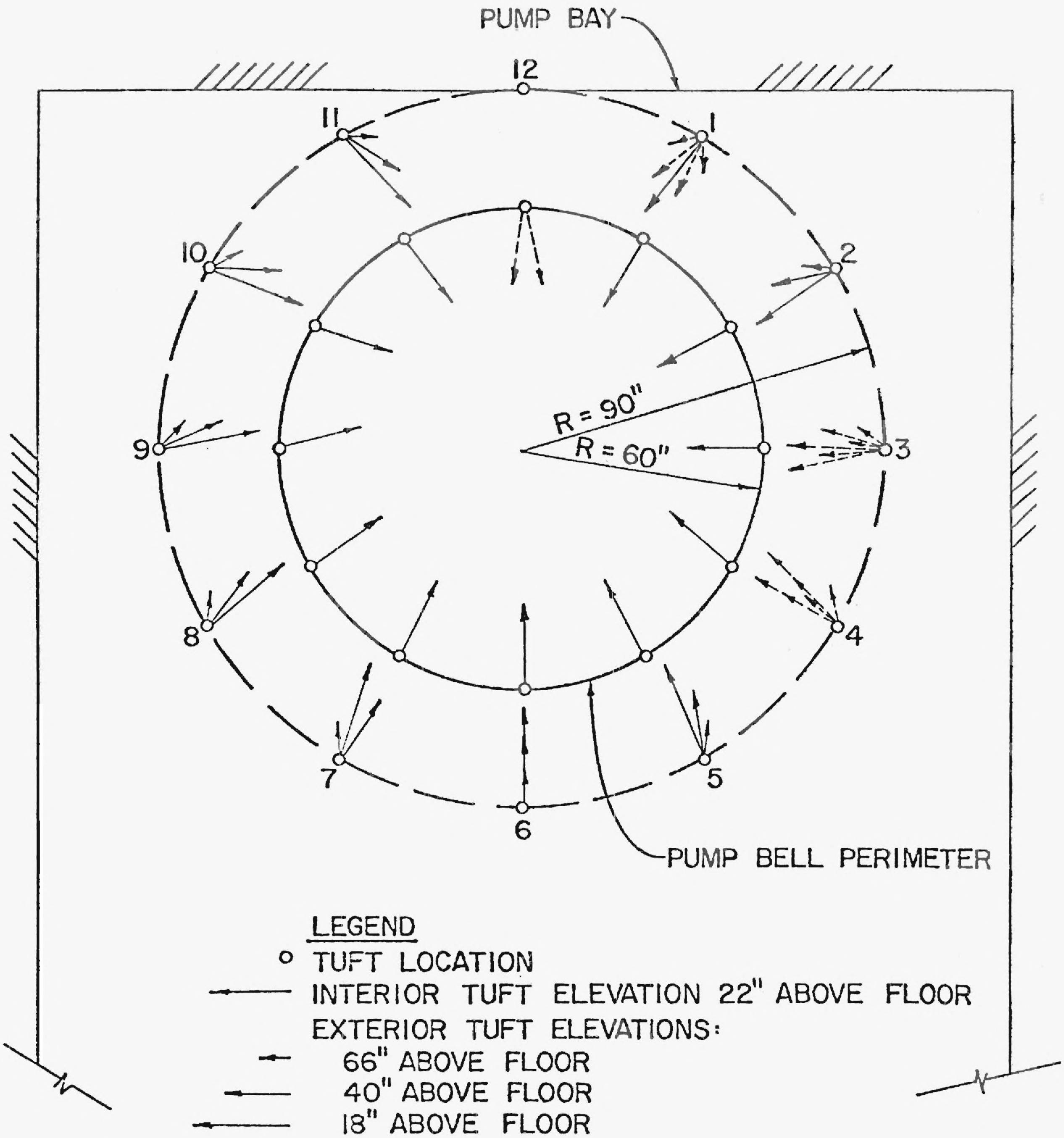


Figure A33. Vogtle II 1:8 Model, Flow Directions at South Pump Bell.
Q = 600 CFS in South Pump Only, No Splitter Wall.

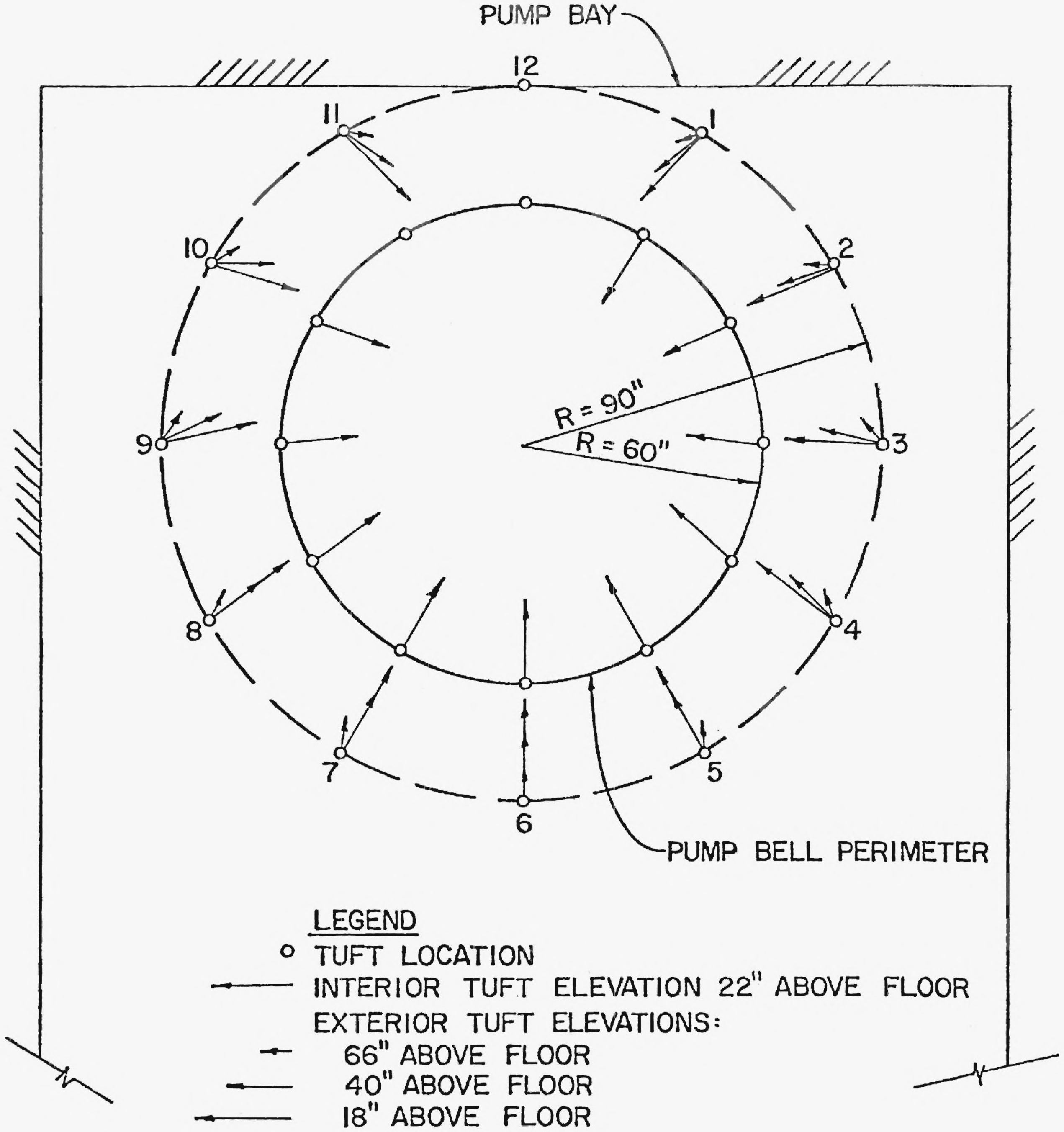


Figure A34. Vogtle II 1:8 Model, Flow Directions at North Suction Bell.
Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 188'.

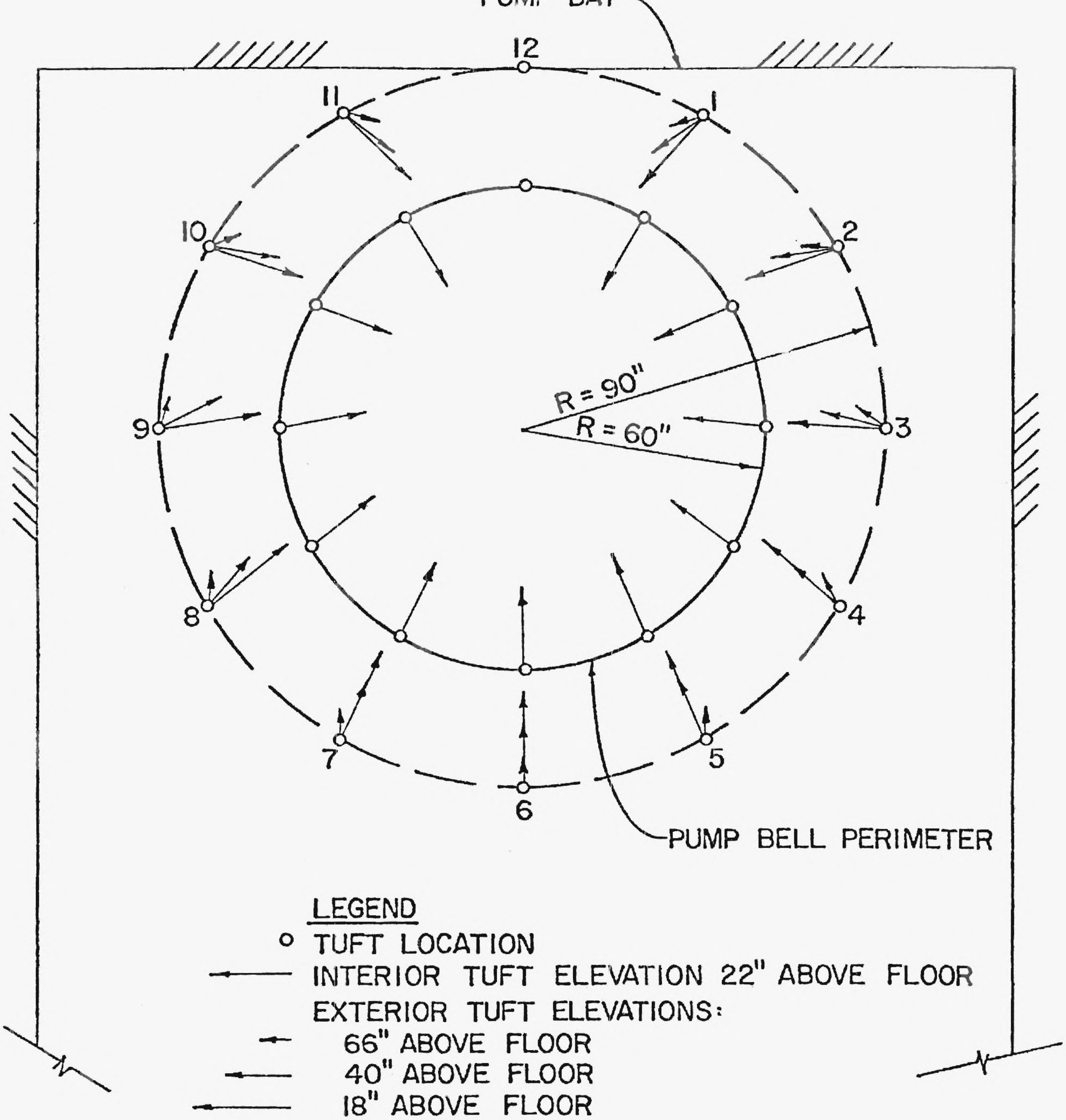


Figure A35. Vogtle II 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 188'.

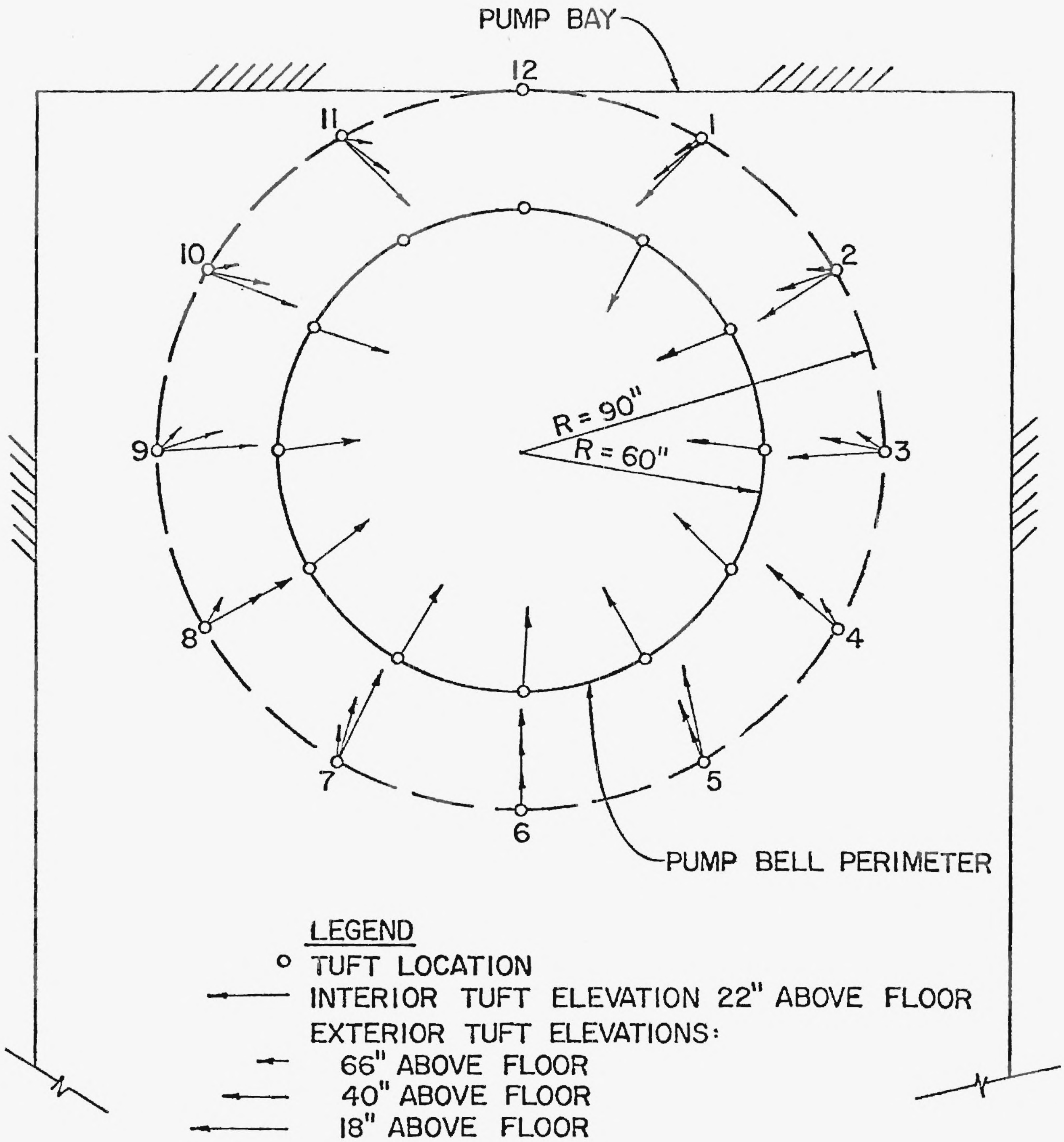


Figure A36. Vogtle II 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 188'.

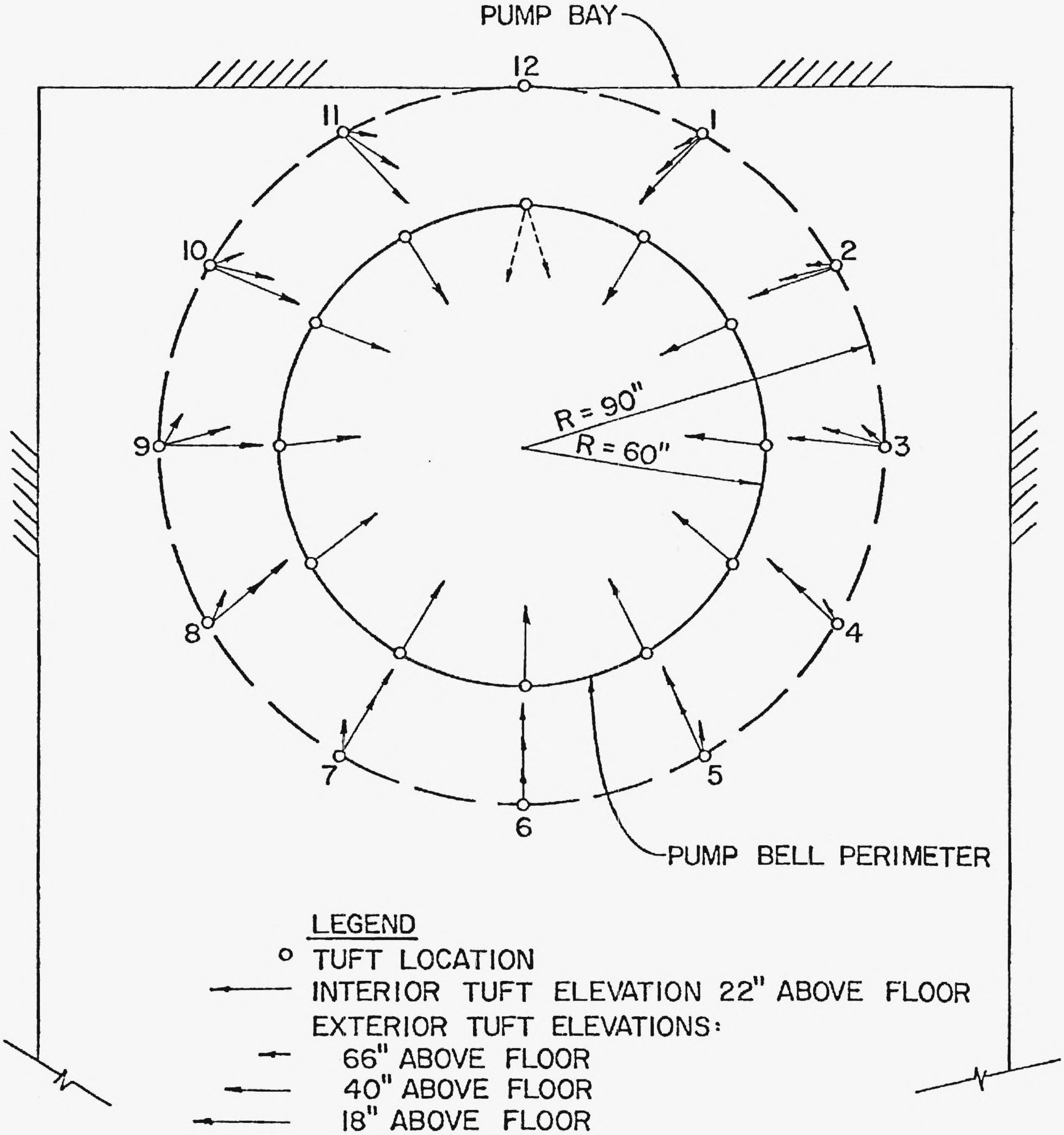


Figure A37. Vogtle II 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in South Pump Only, Splitter Wall to Elevation 188'.

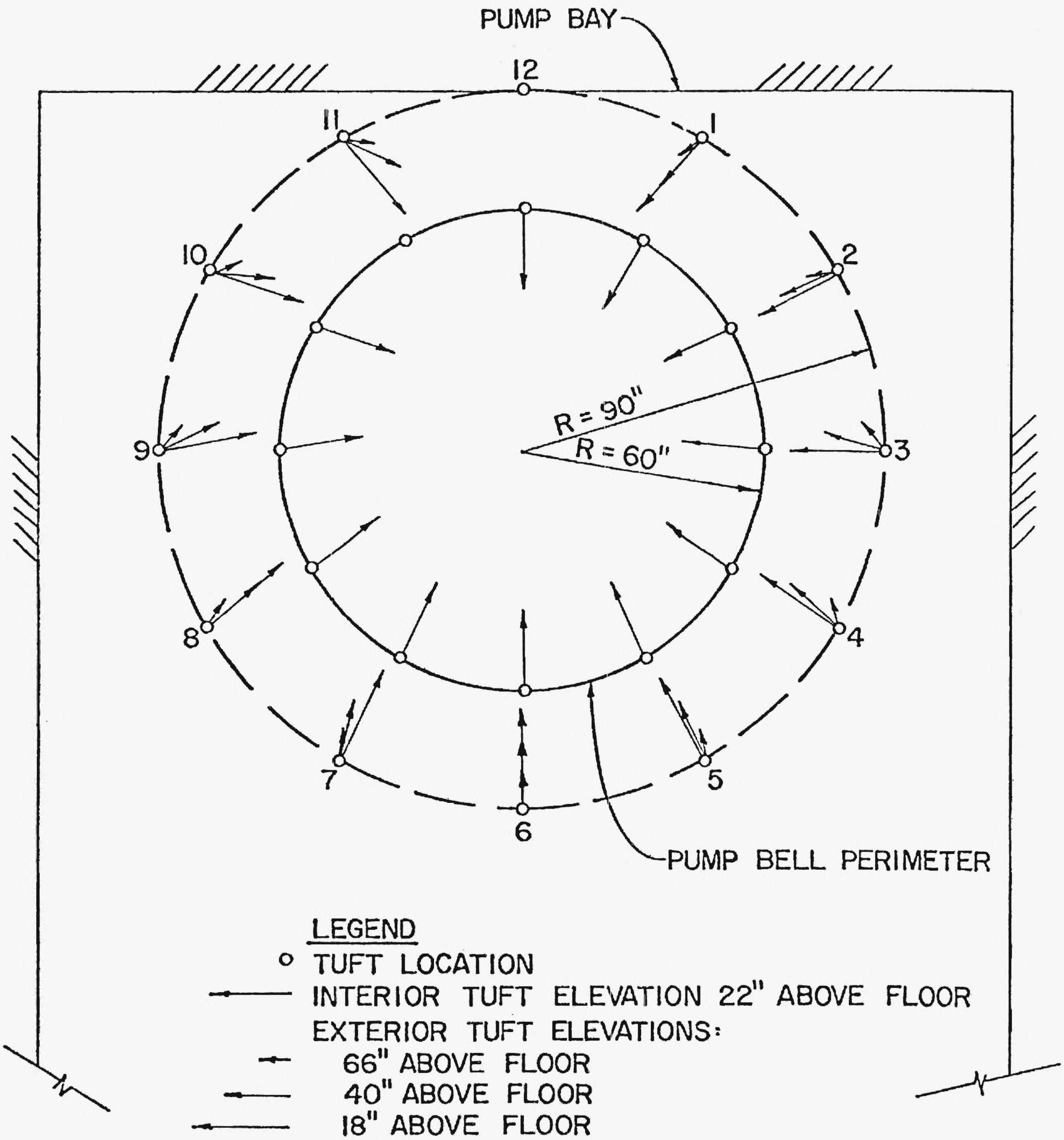


Figure A38. Vogtle II 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 195'.

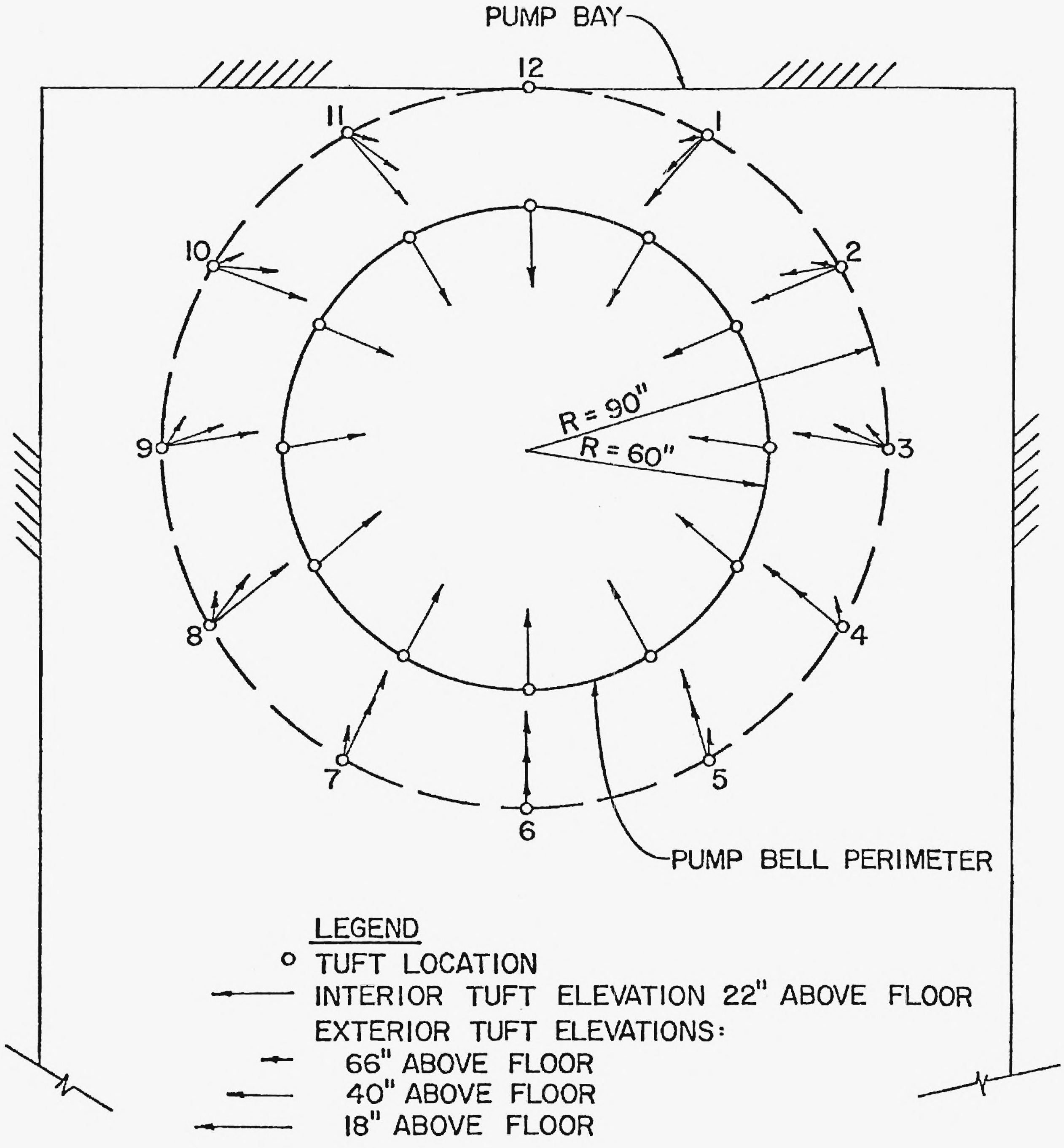


Figure A39. Vogtle II 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 195'.

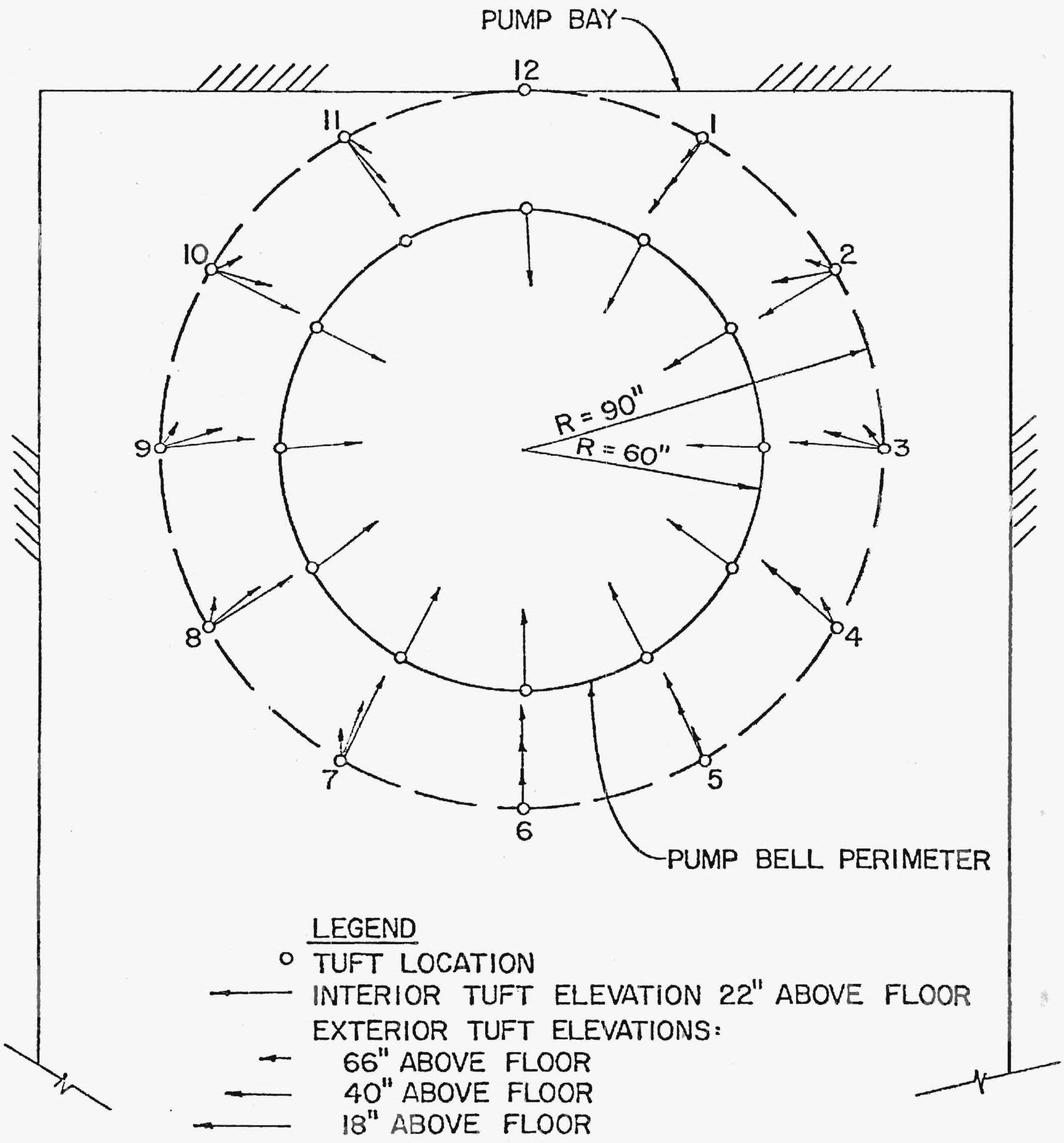


Figure A40. Vogtle II 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 195'.

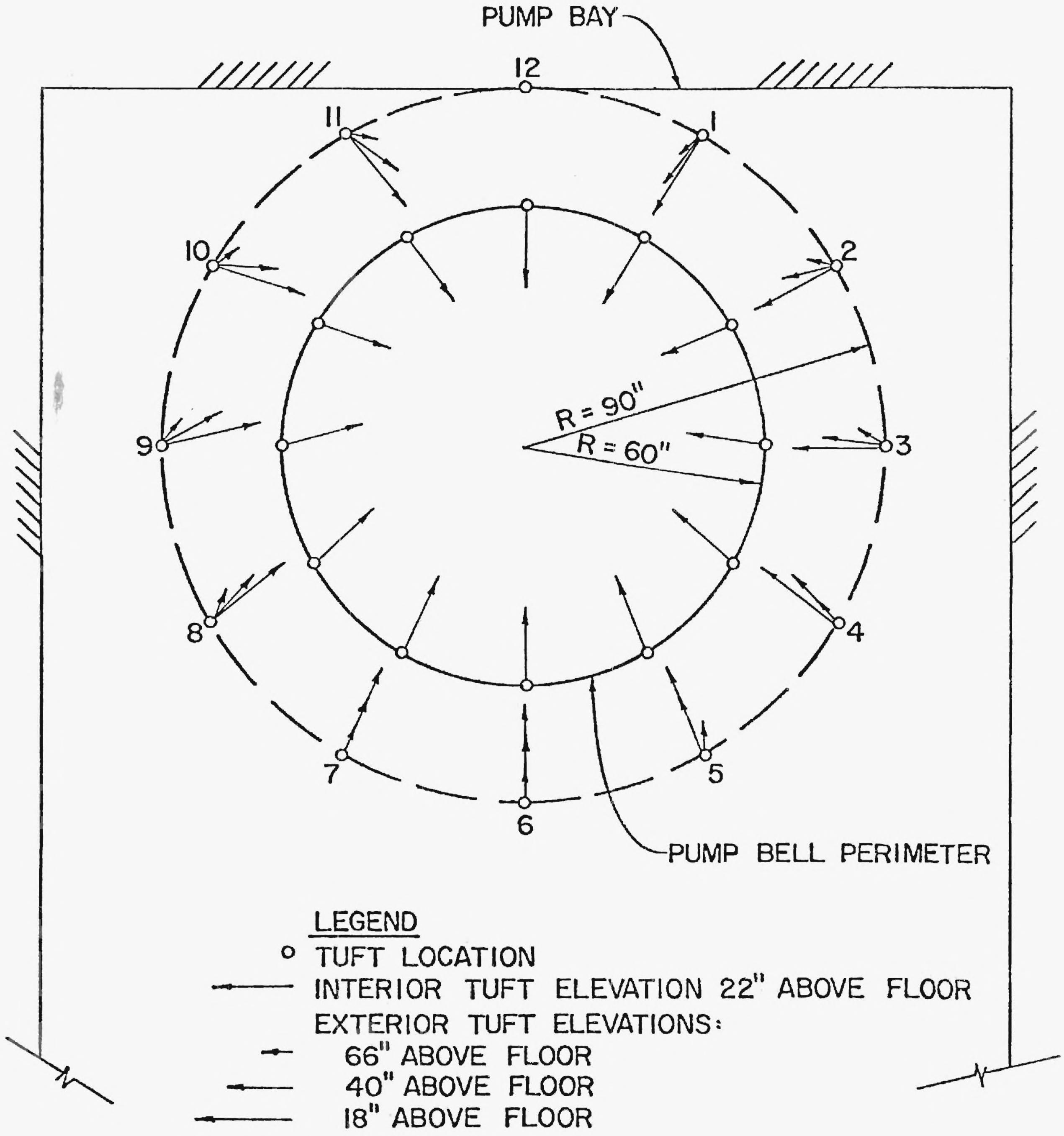


Figure A41. Vogtle II 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in South Pump Only, Splitter Wall to Elevation 195'.

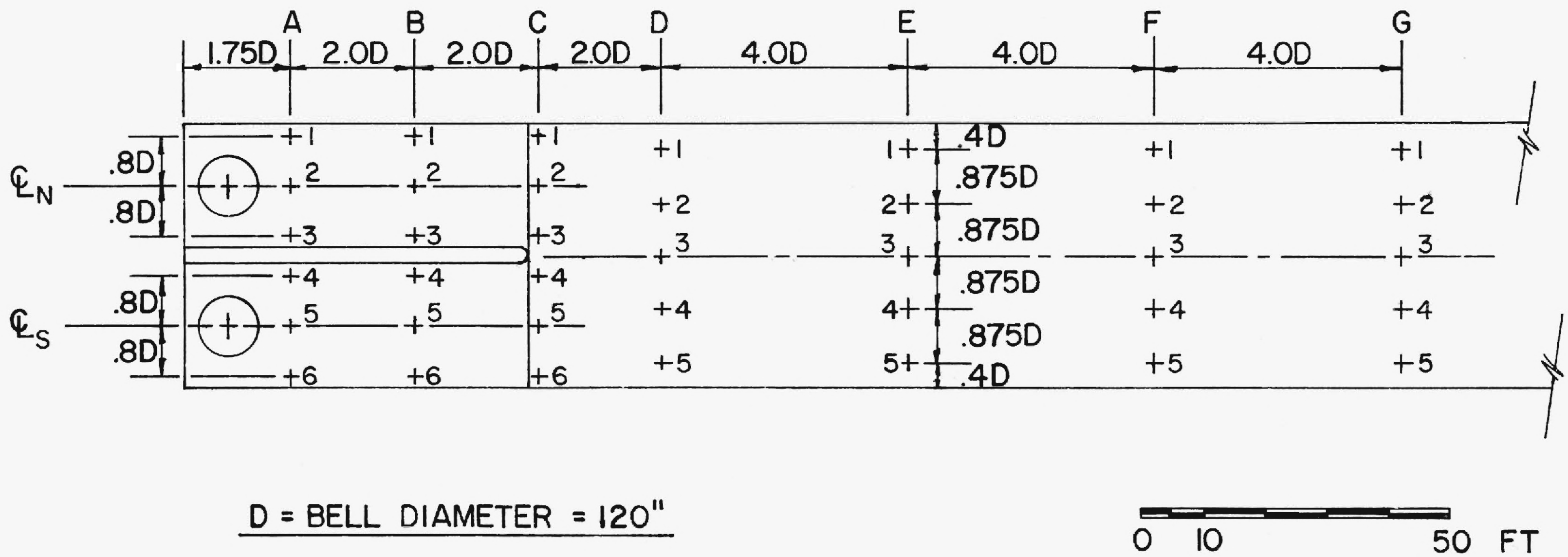


Figure A42. Vogtle III 1:8 Model, Velocity Measuring Stations.

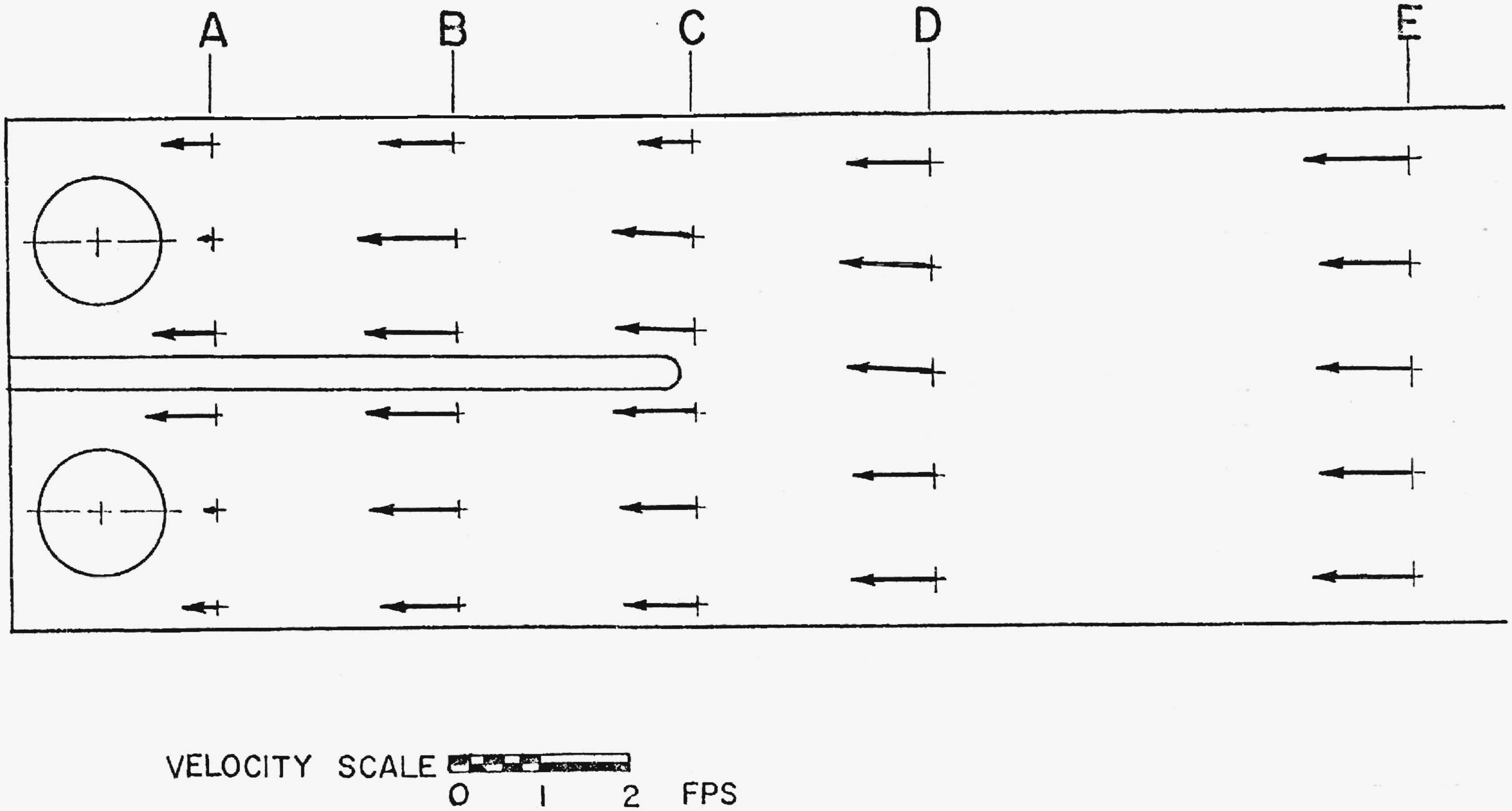


Figure A43. Vogtle III 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 191'.

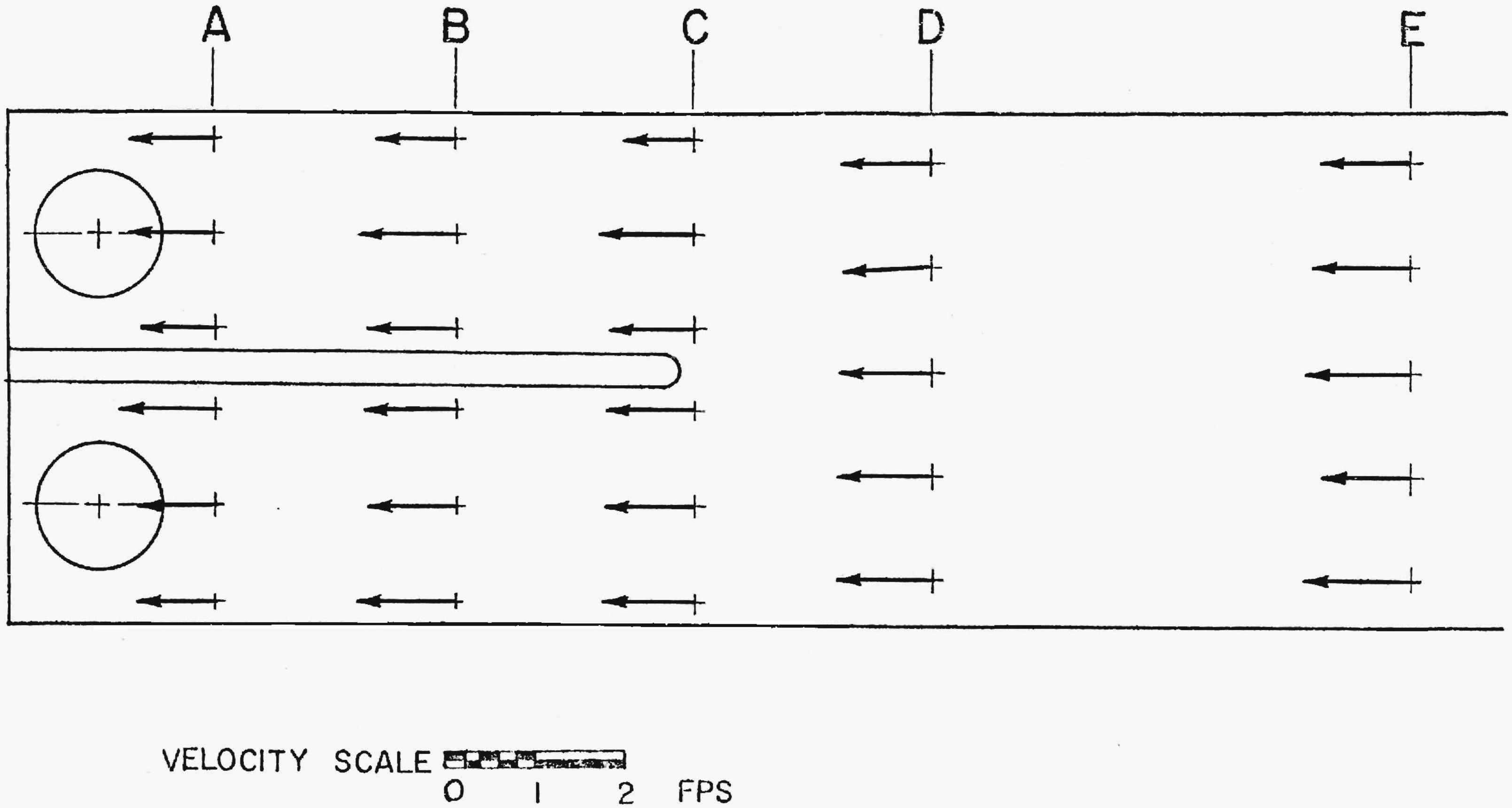


Figure A44. Vogtle III 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 191'.

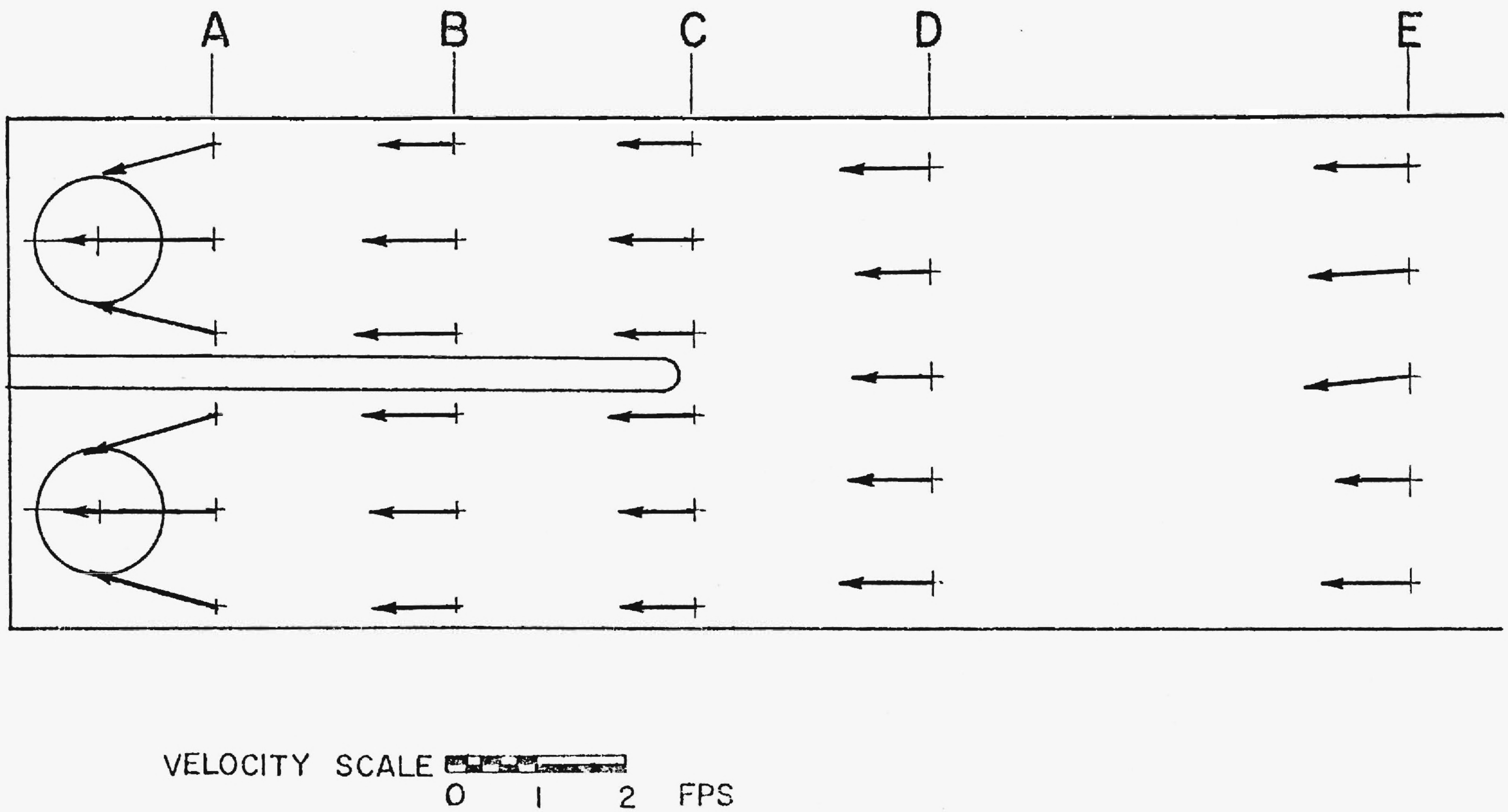


Figure A45. Vogtle III 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 191'.

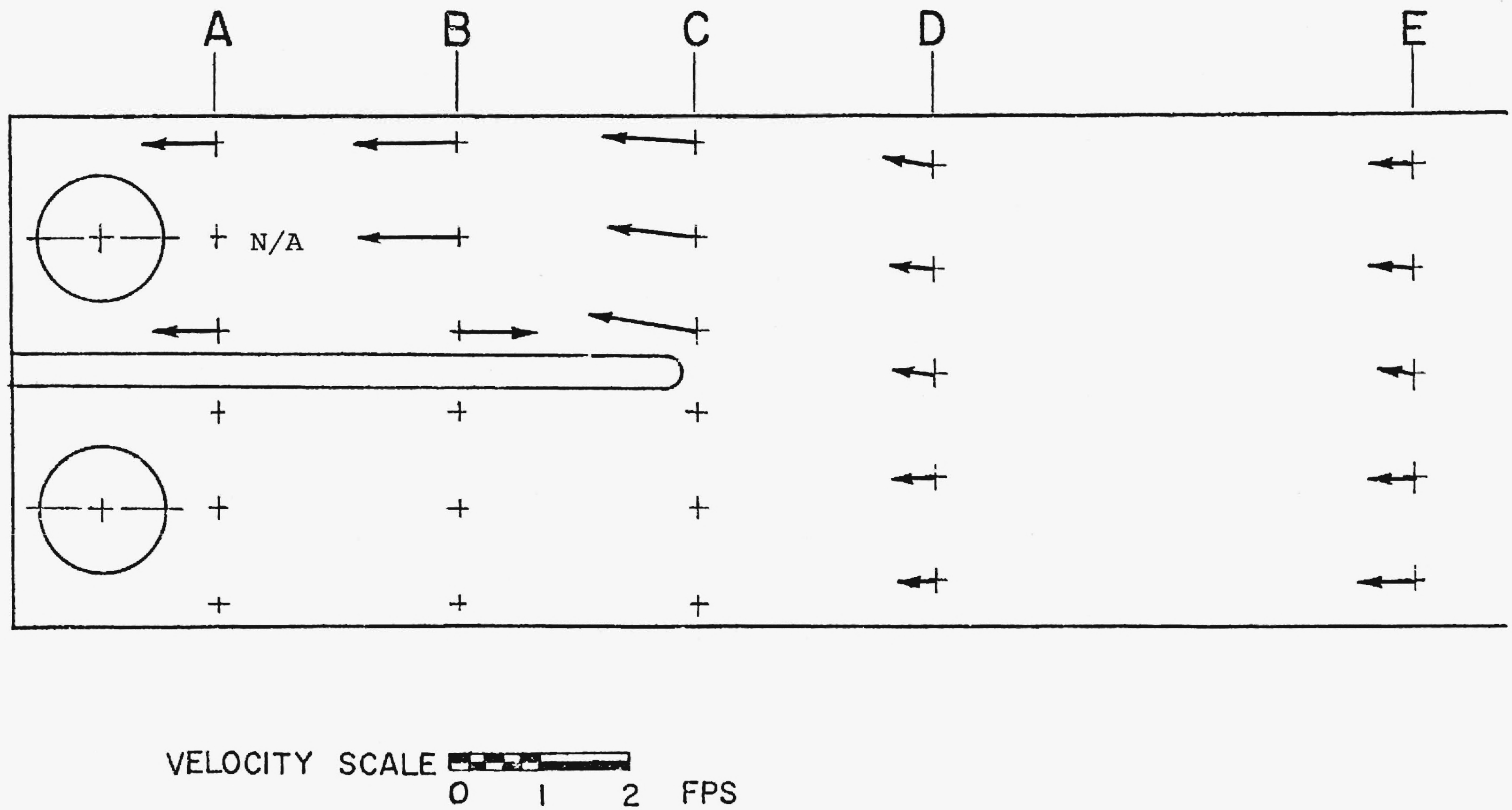


Figure A46. Vogtle III 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 191'.

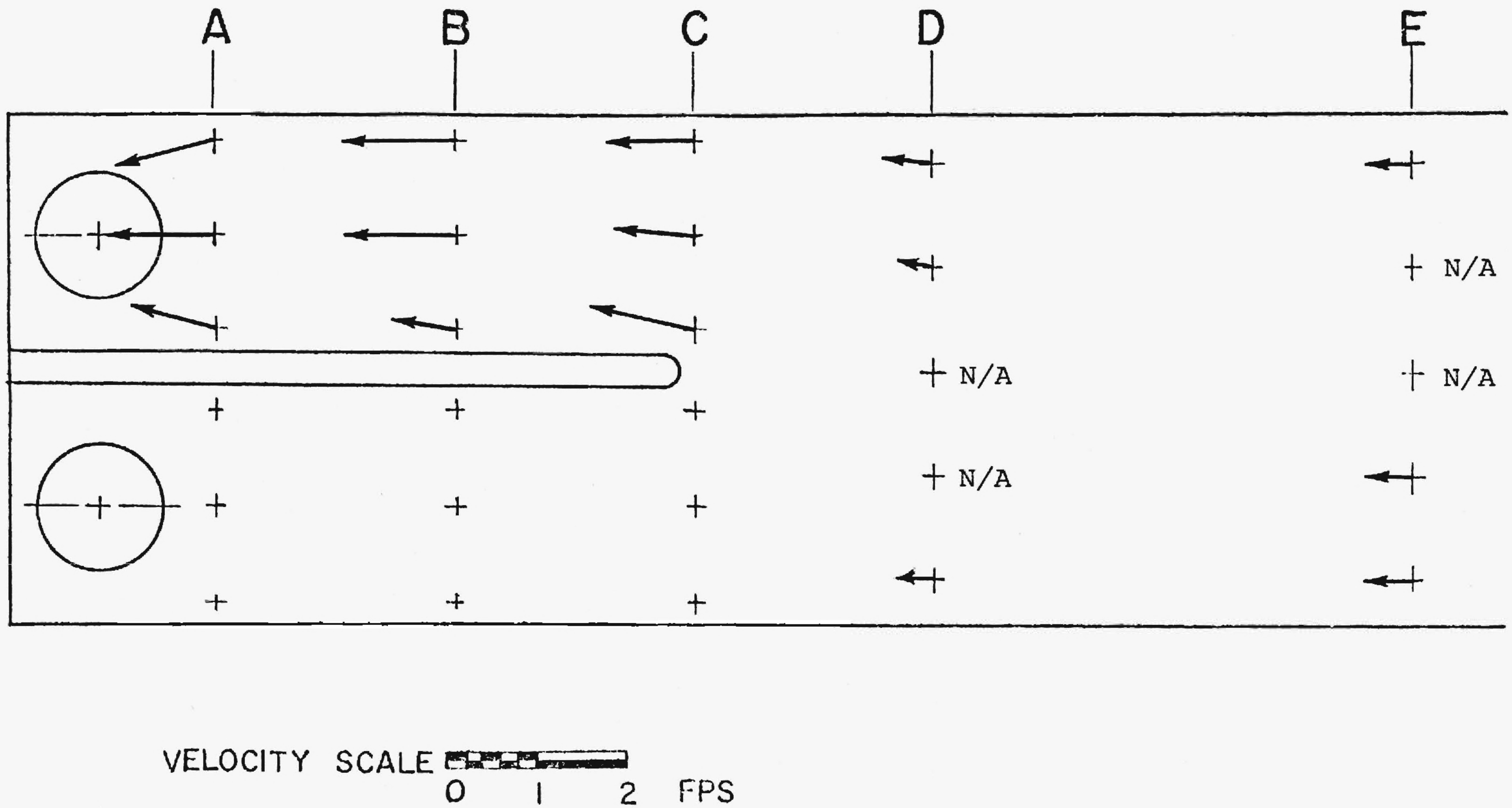


Figure A47. Vogtle III 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 191'.

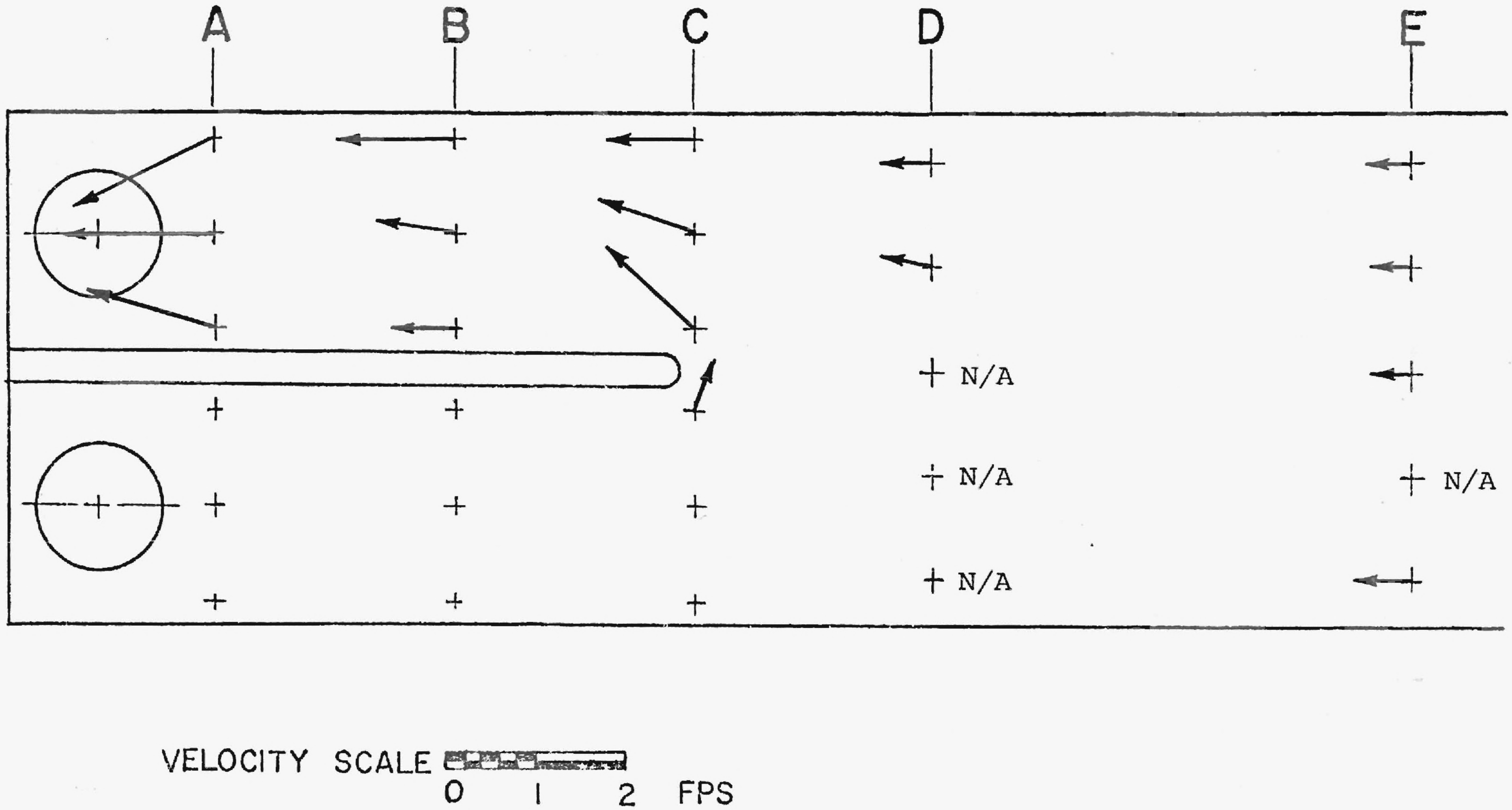


Figure A48. Vogtle III 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 191'.

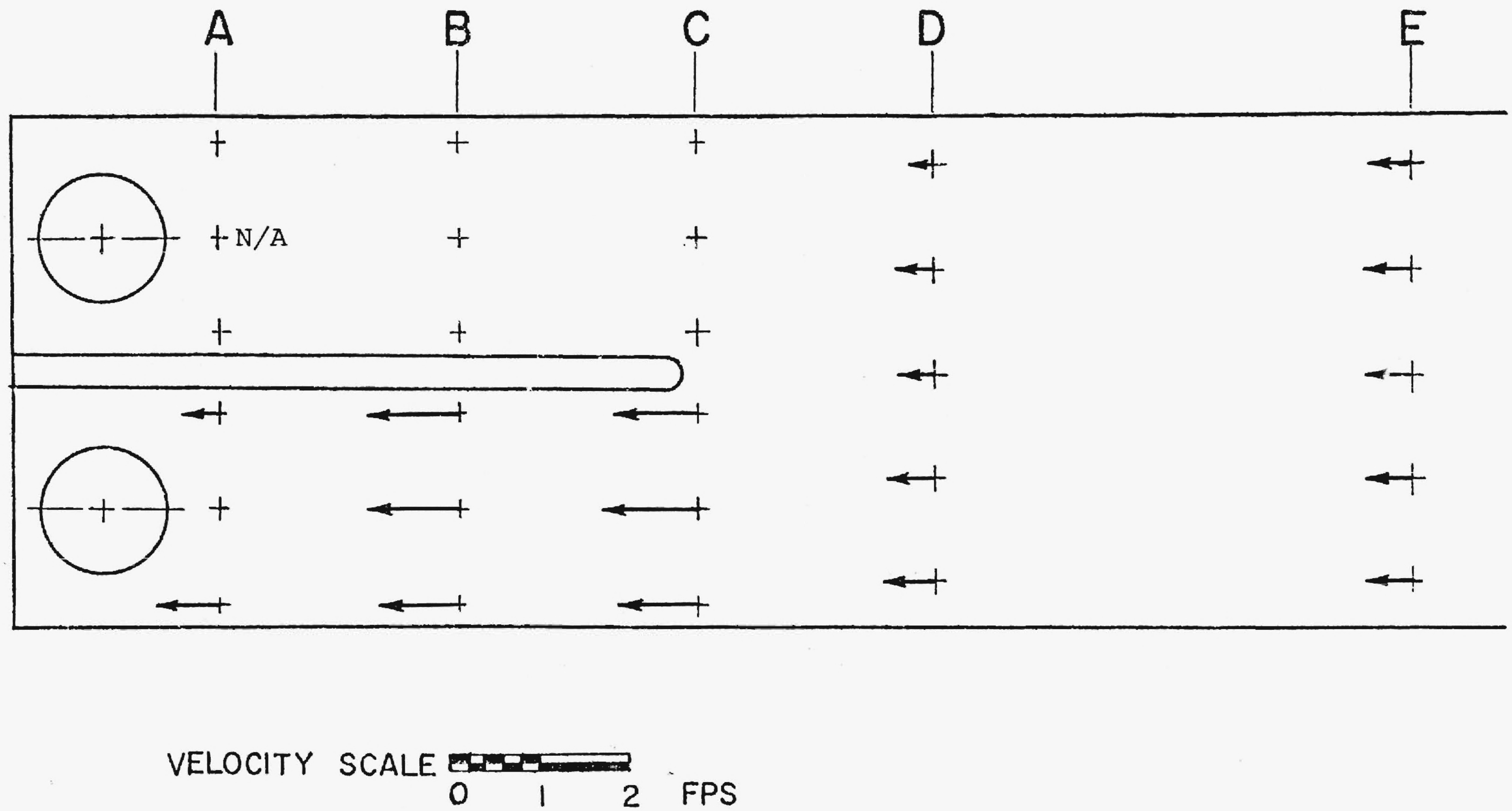


Figure A49. Vogtle III 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in South Pump Only, Splitter Wall to Elevation 191'.

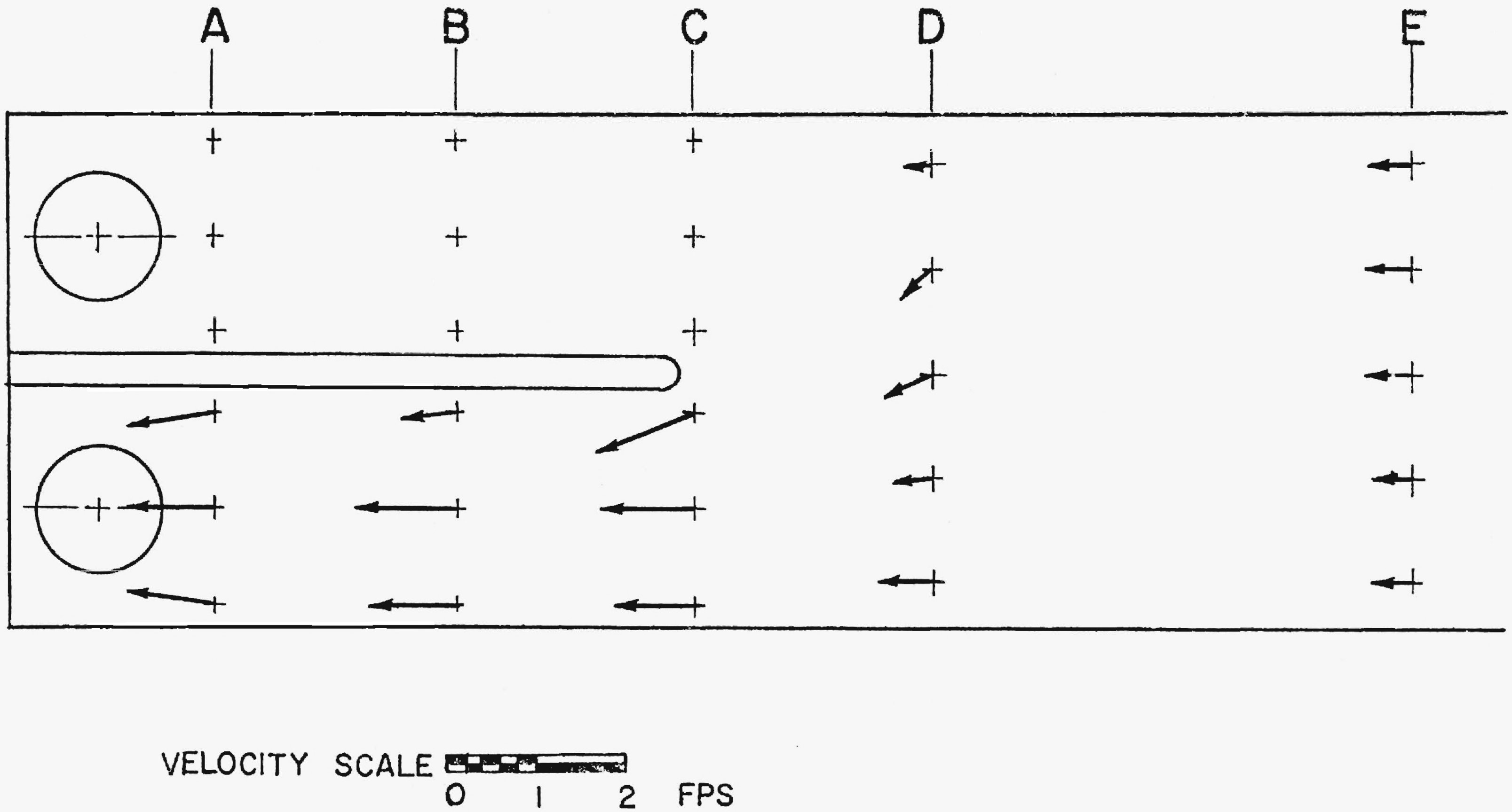


Figure A50. Vogtle III 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in South Pump Only, Splitter Wall to Elevation 191'.

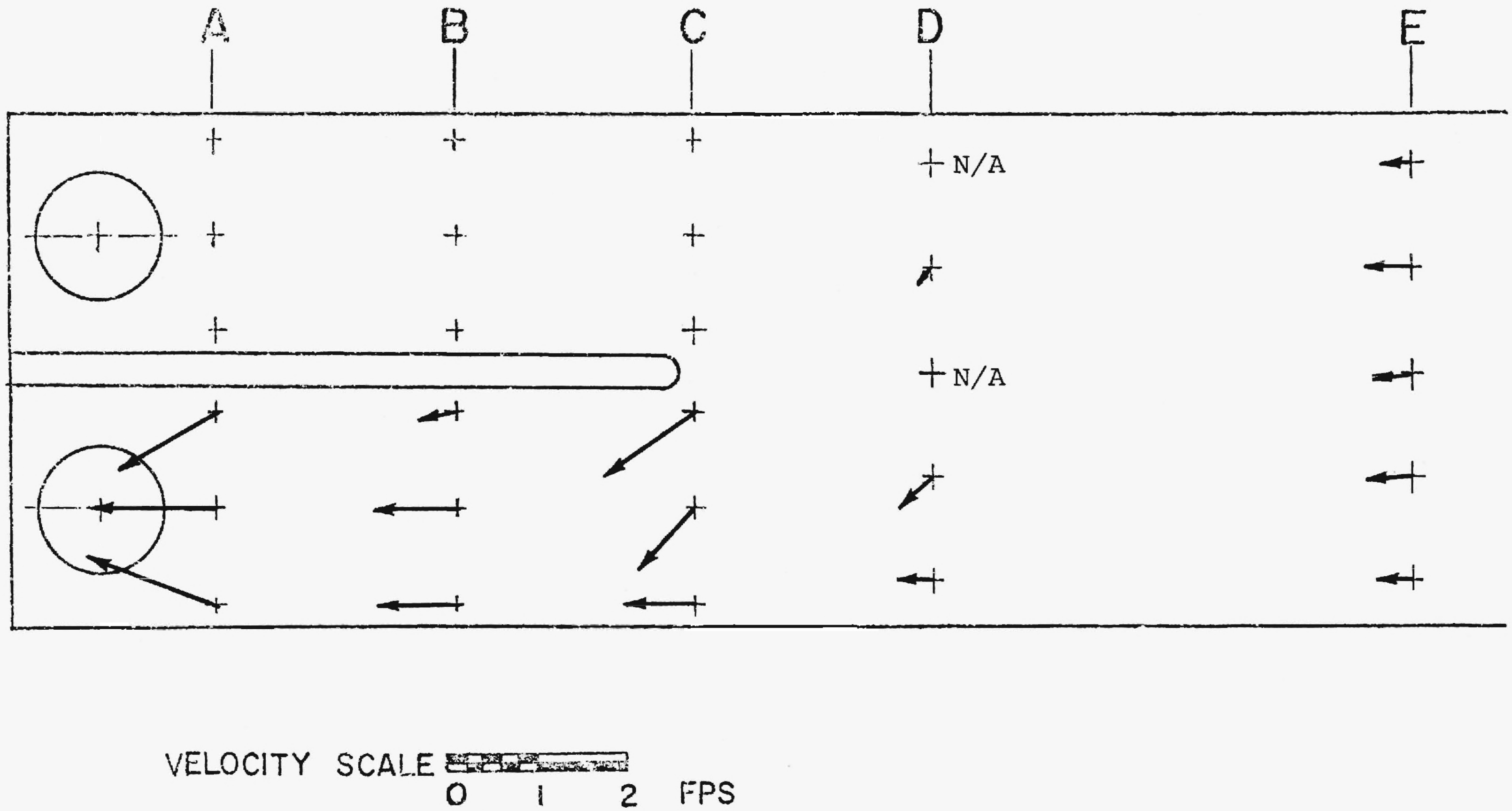


Figure A51. Vogtle III 1:8 Model, Vectors 2' Above Floor.
Q = 600 CFS in South Pump Only, Splitter Wall
to Elevation 191'.

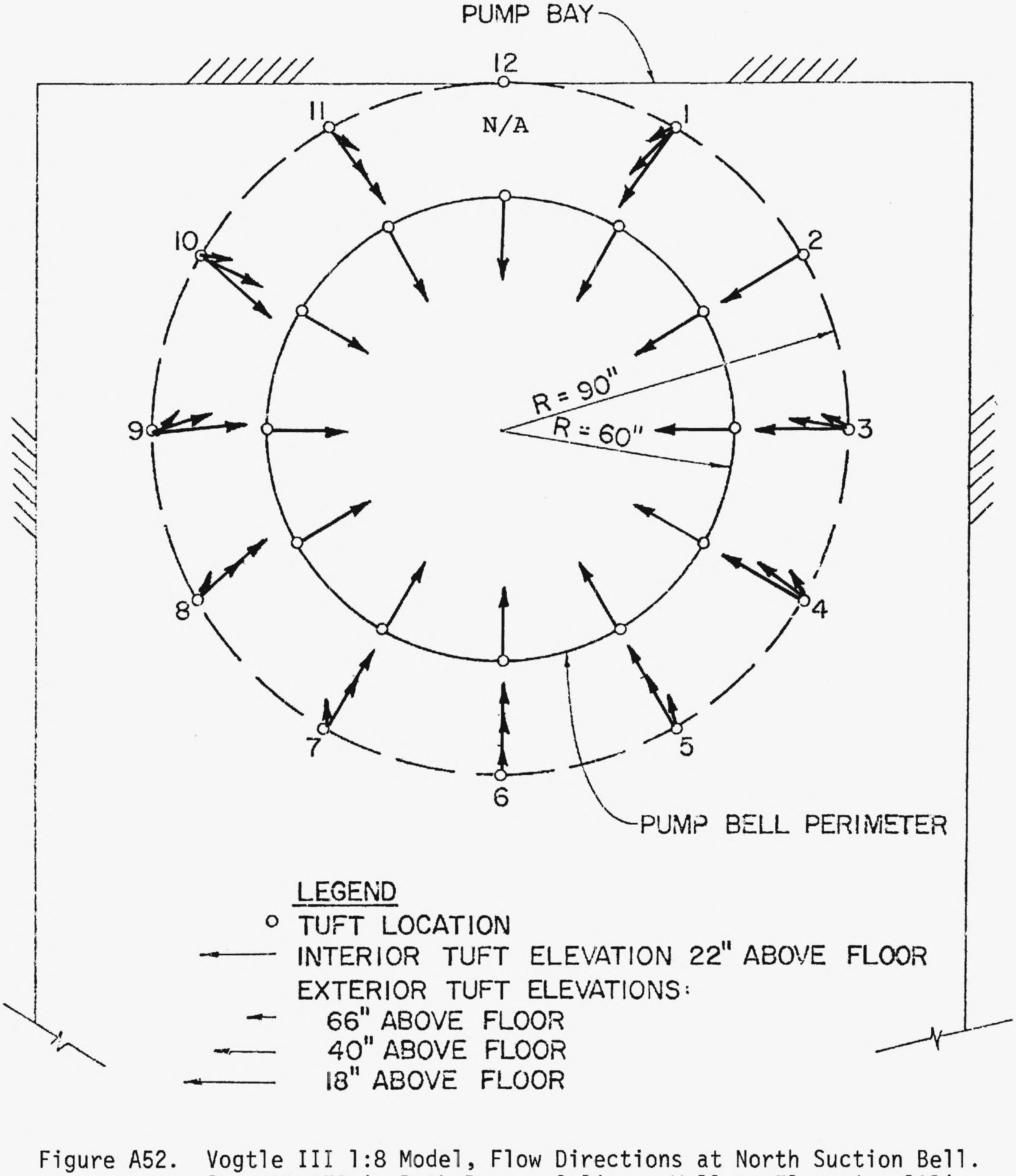


Figure A52. Vogtle III 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 191'.

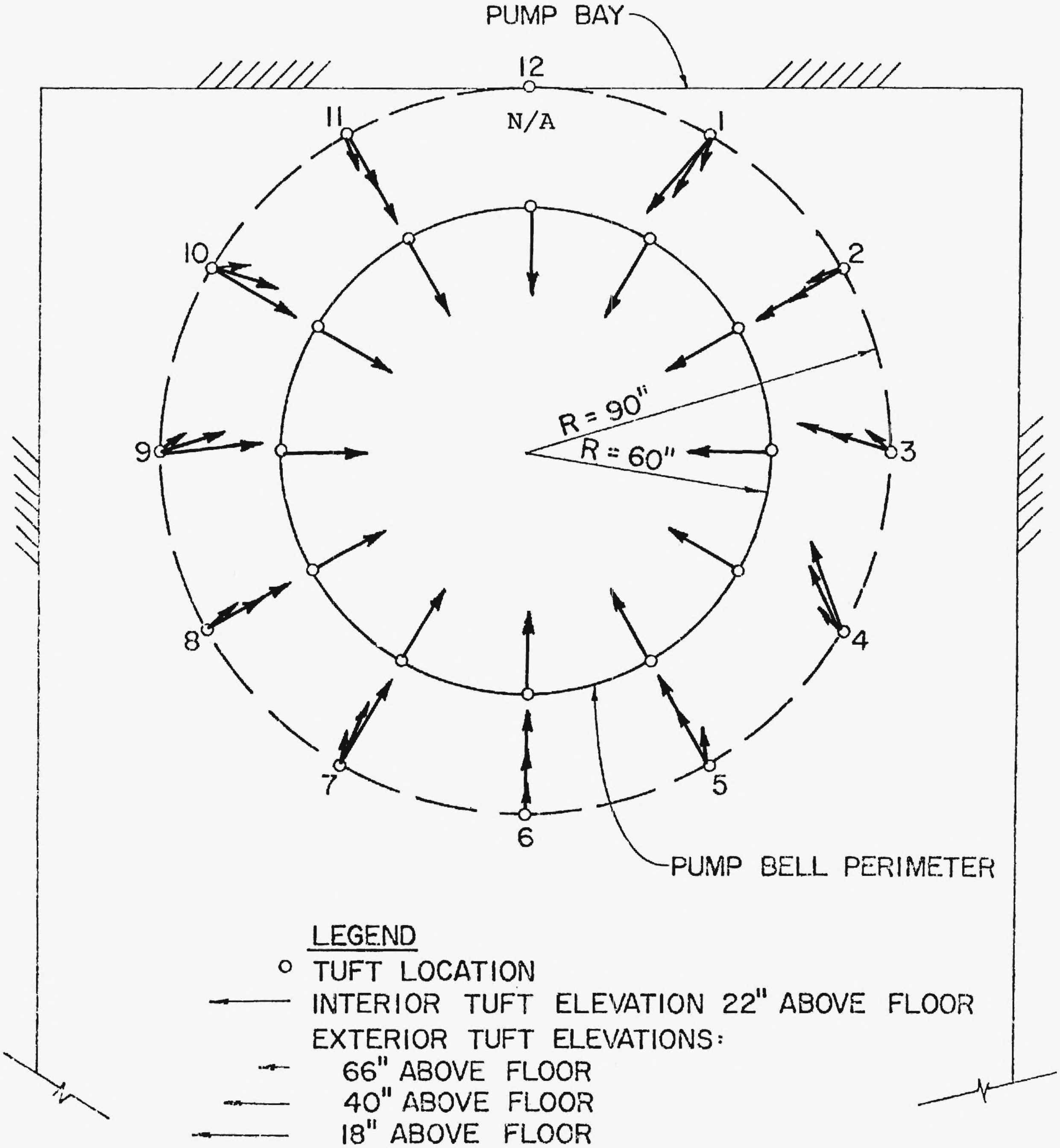


Figure A53. Vogtle III 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in Both Pumps, Splitter Wall to Elevation 191'.

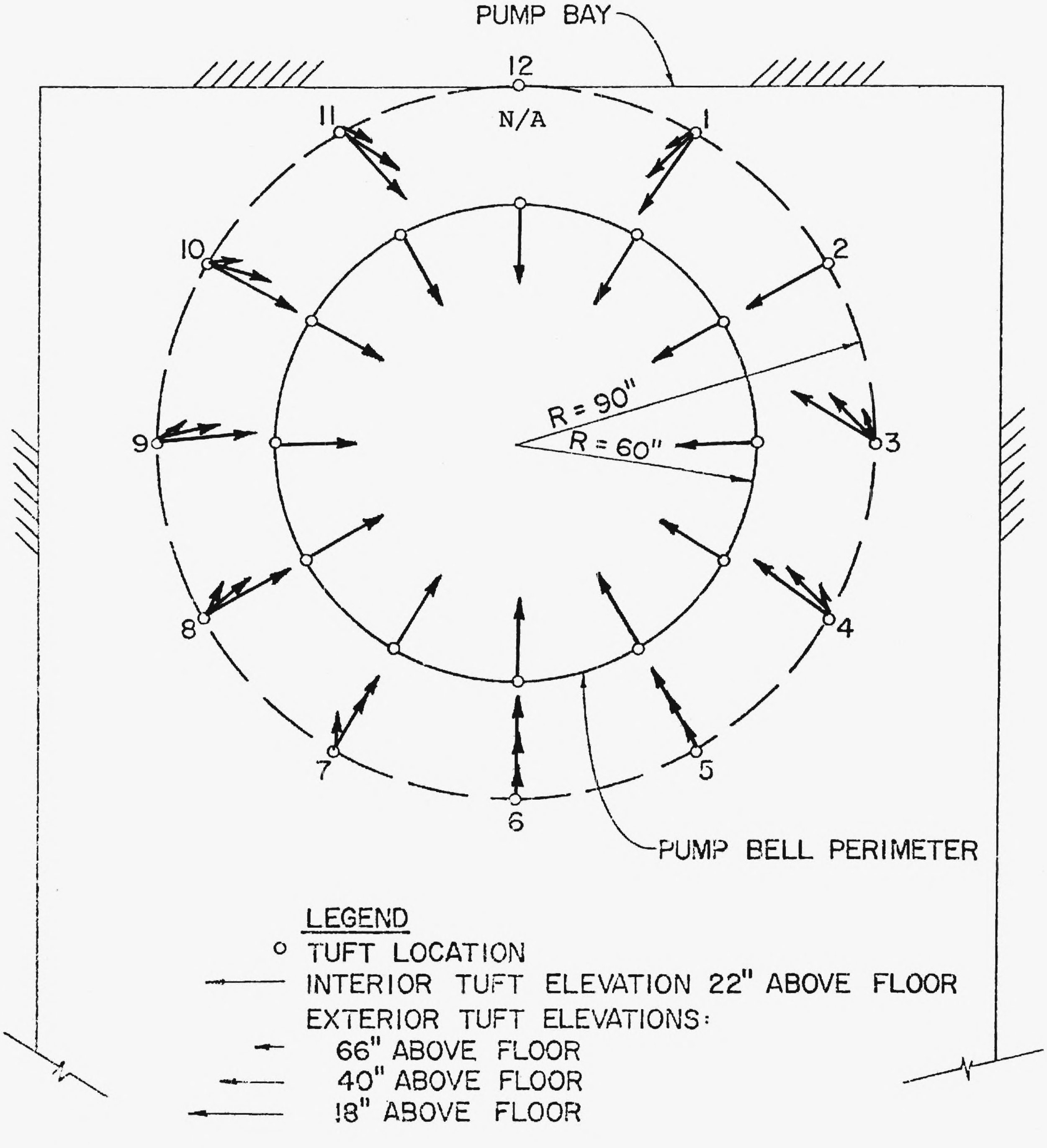


Figure A54. Vogtle III 1:8 Model, Flow Directions at North Suction Bell. Q = 600 CFS in North Pump Only, Splitter Wall to Elevation 191'.

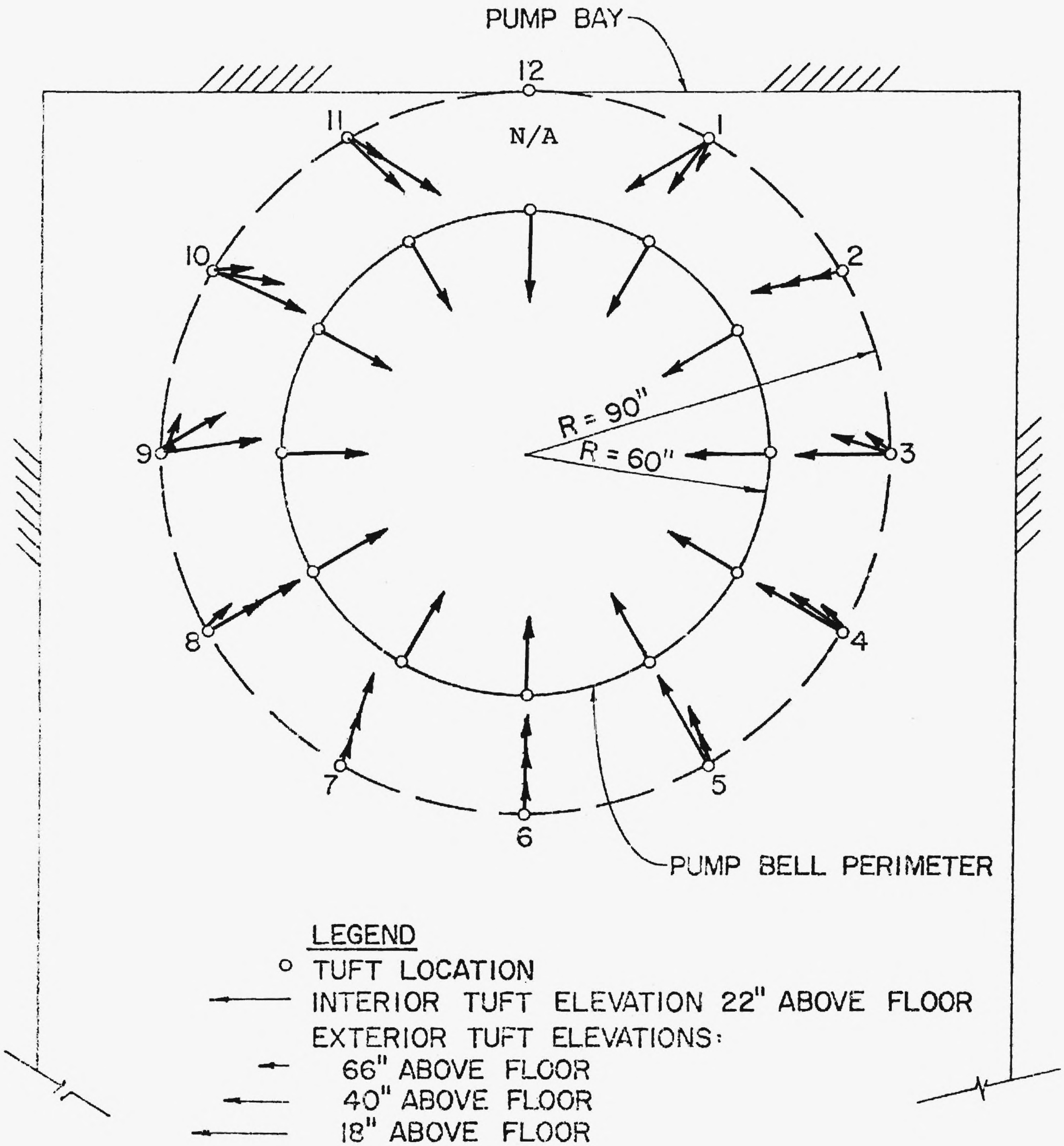


Figure A55. Vogtle III 1:8 Model, Flow Directions at South Suction Bell. Q = 600 CFS in South Pump Only, Splitter Wall to Elevation 191'.

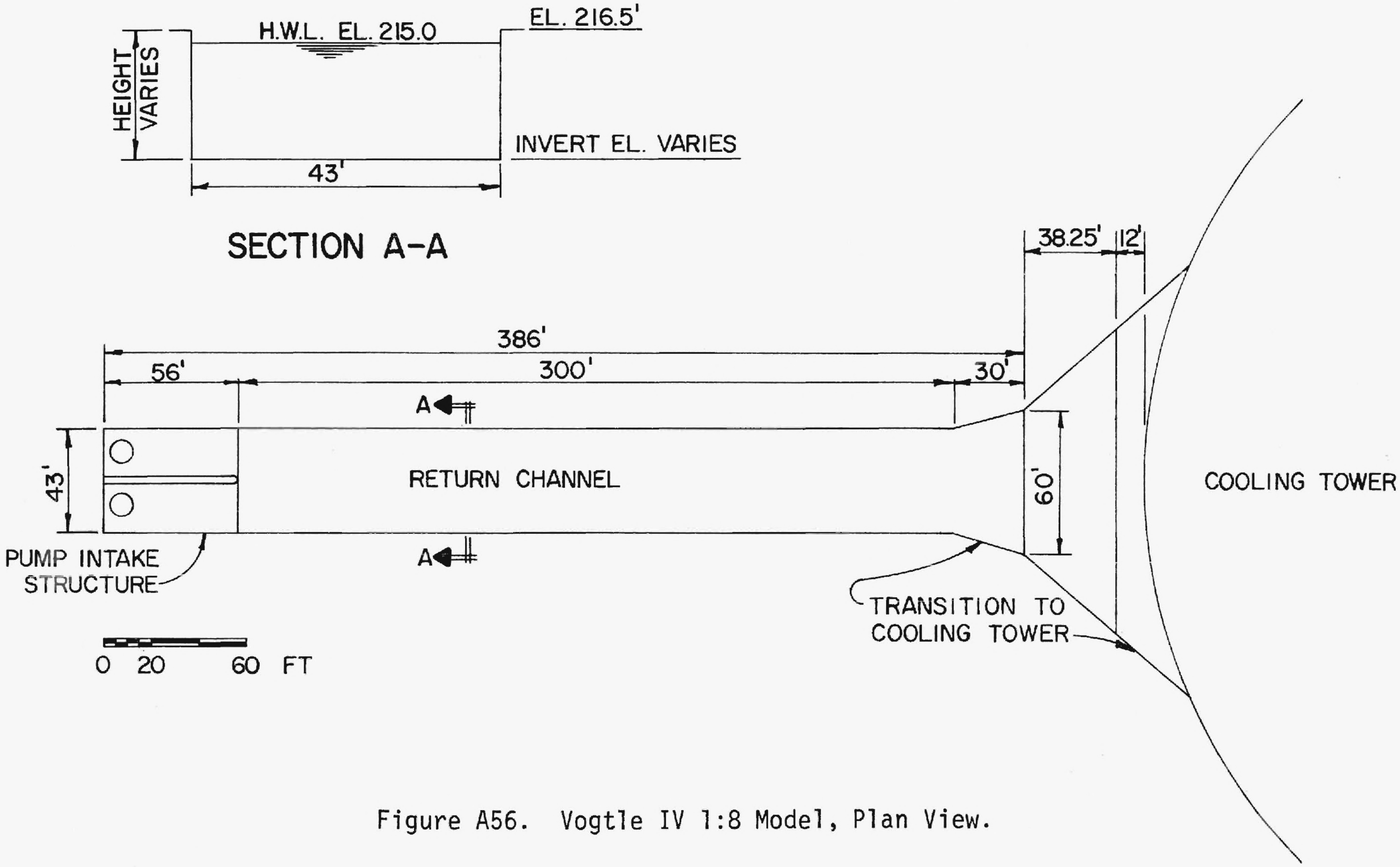


Figure A56. Vogtle IV 1:8 Model, Plan View.

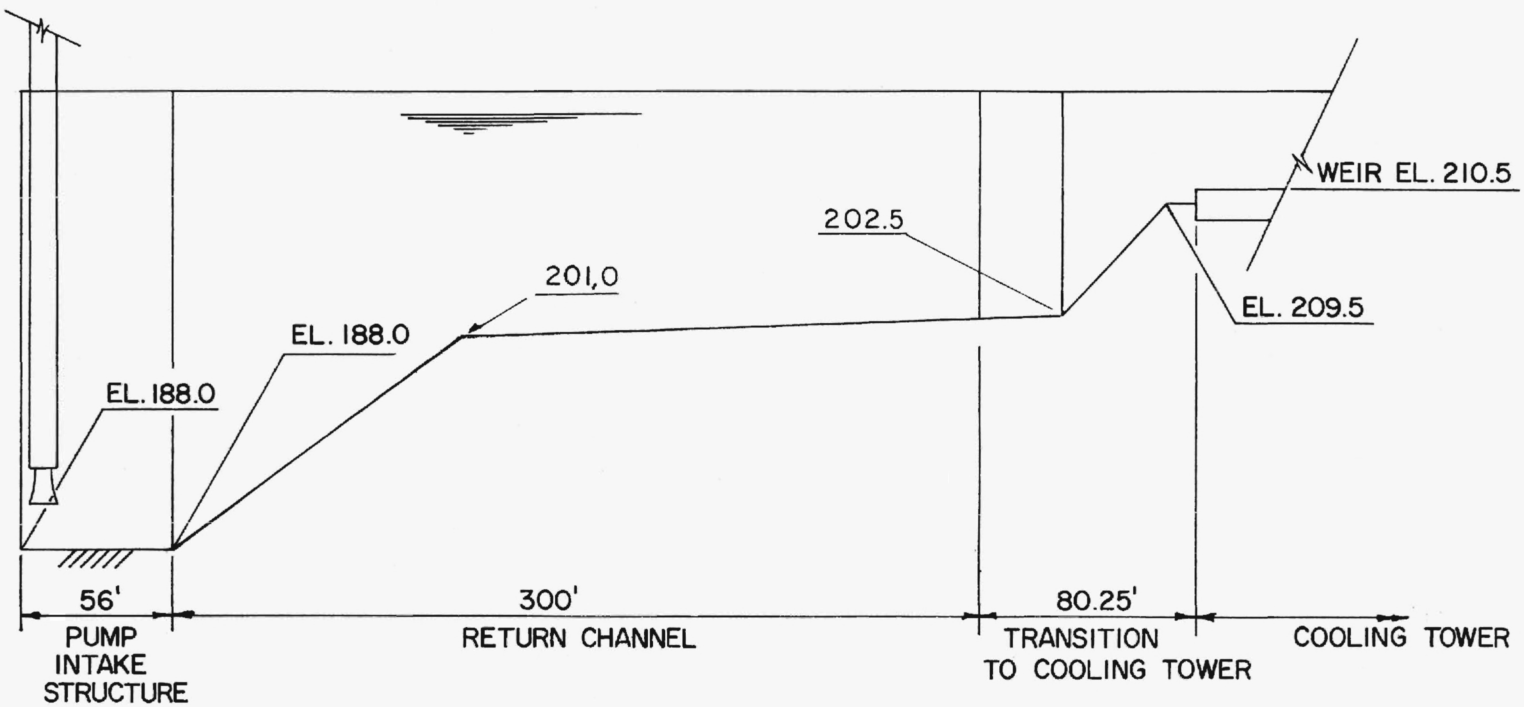


Figure A57. Vogtle IV 1:8 Model, Longitudinal Profile.

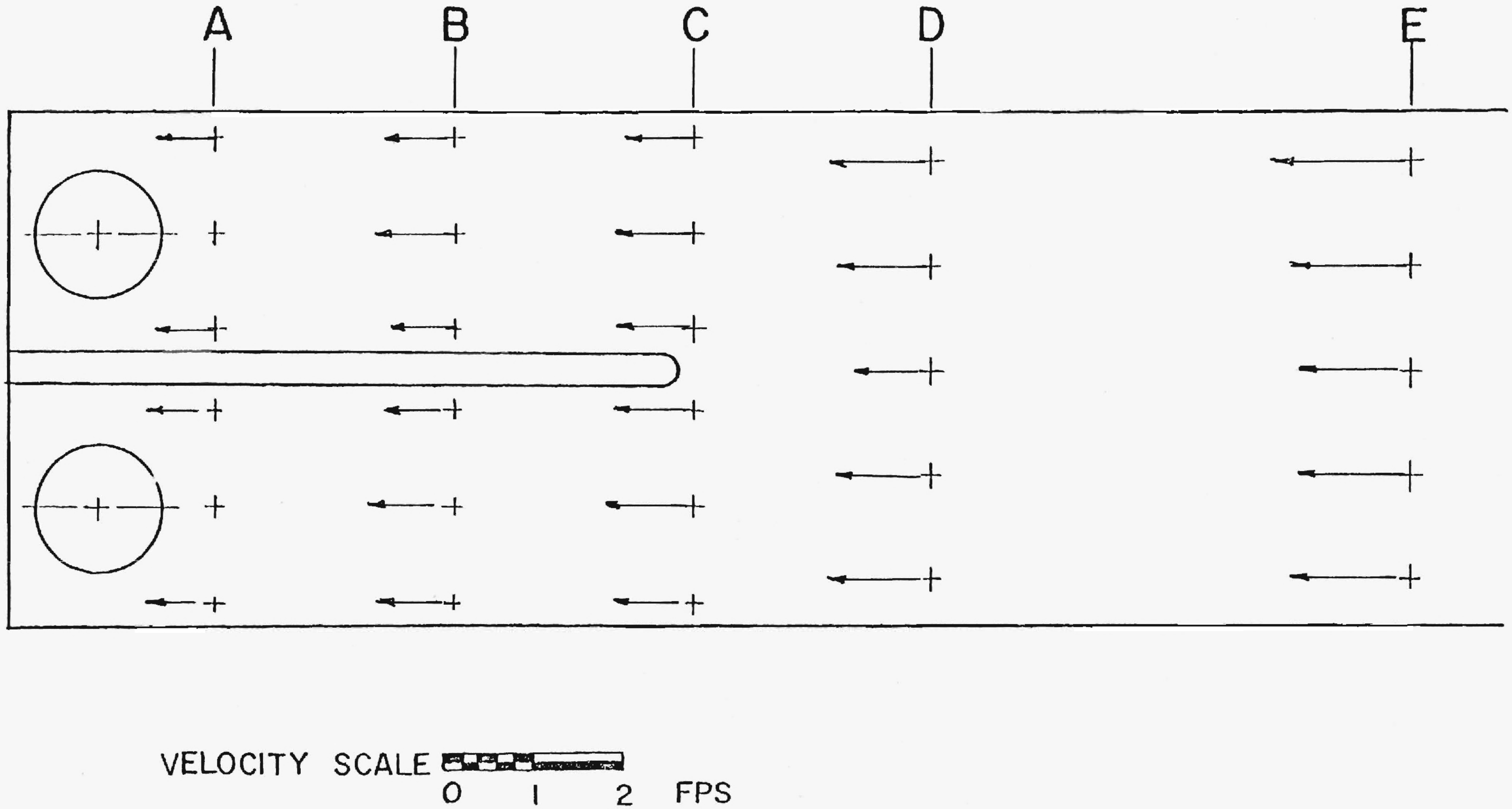


Figure A58. Vogtle IV 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in Both Pumps.

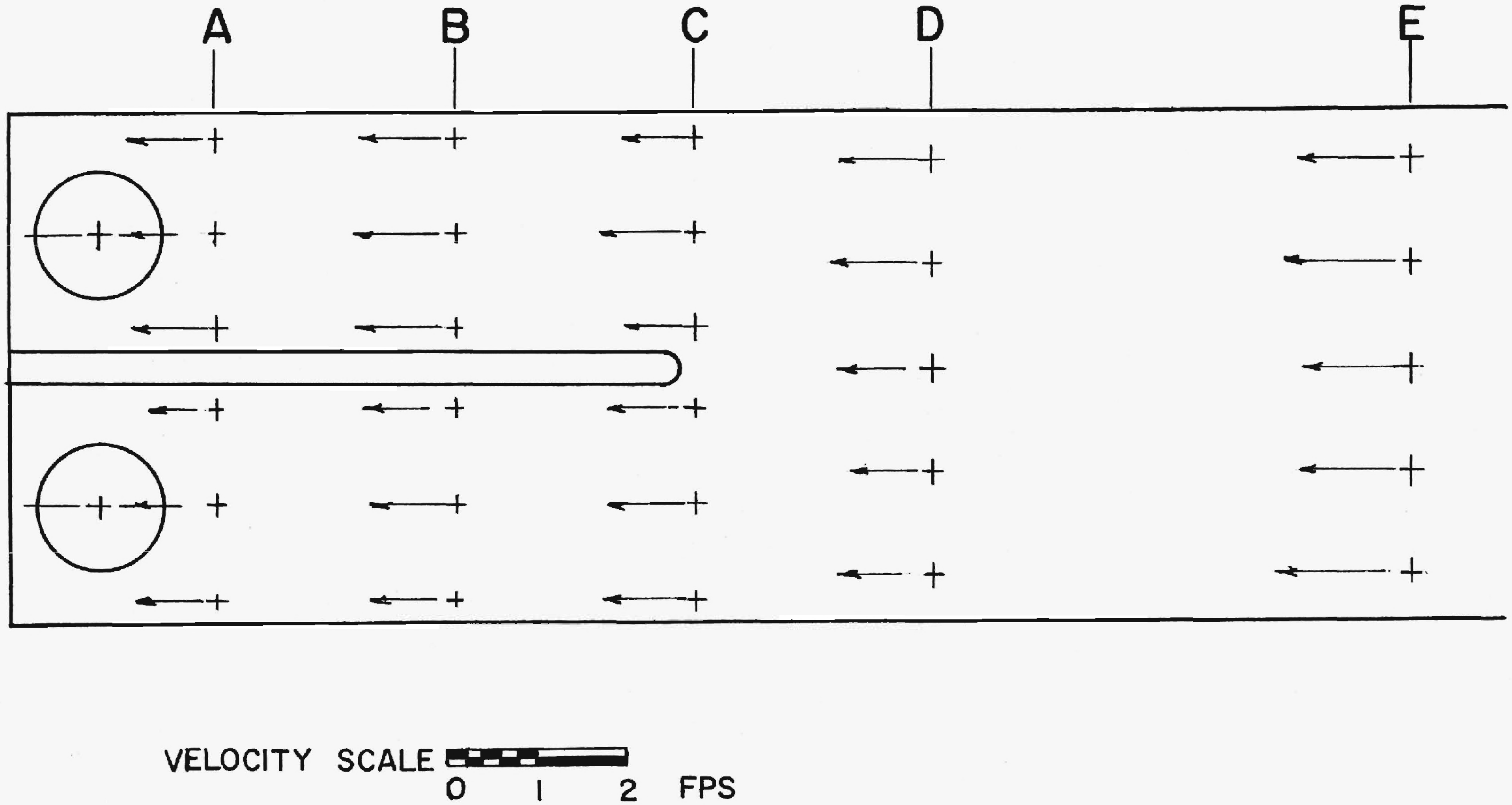


Figure A59. Vogtle IV k:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in Both Pumps.

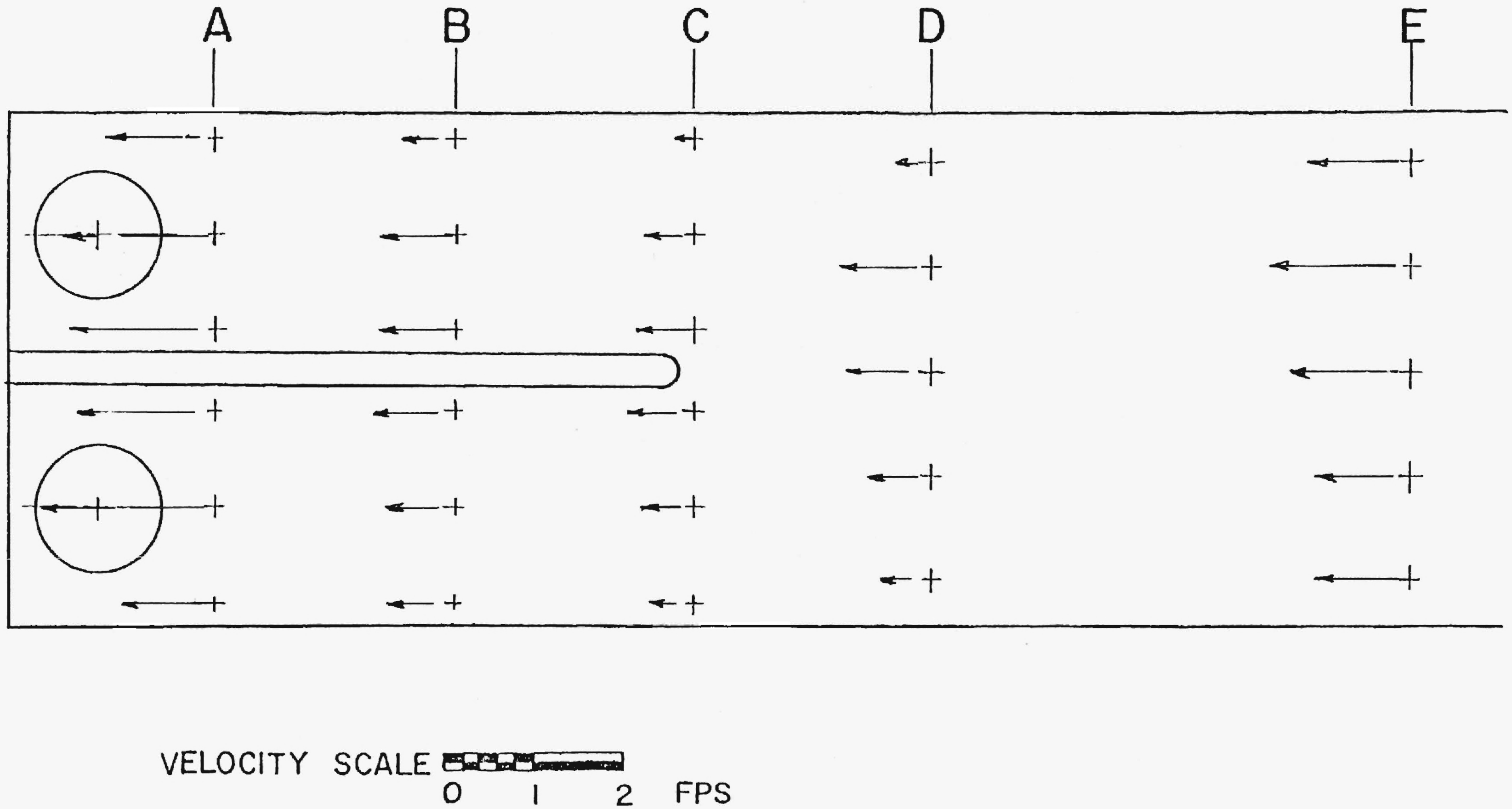


Figure A60. Vogtle IV 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in Both Pumps.

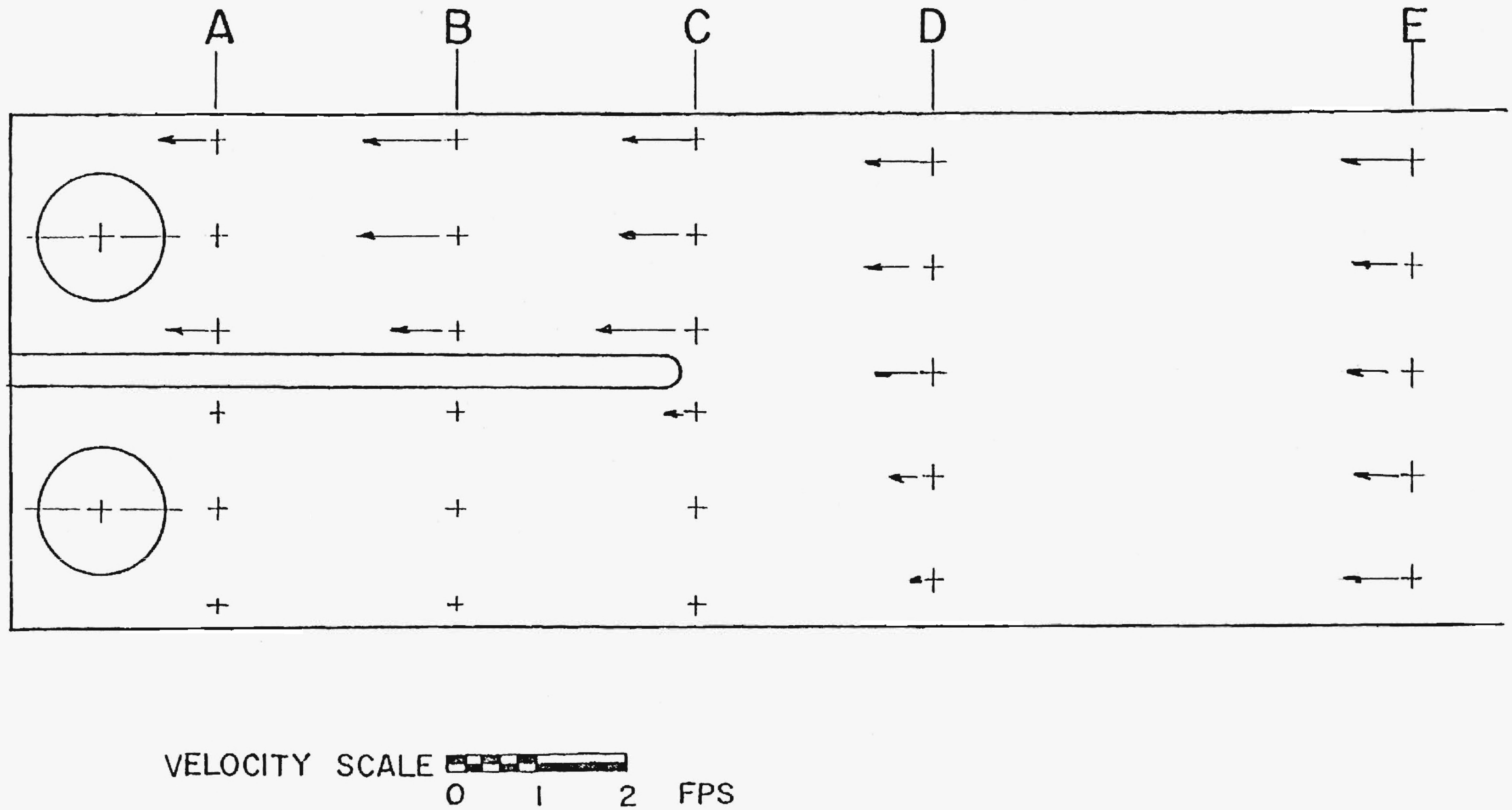


Figure A61. Vogtle IV 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in North Pump Only.

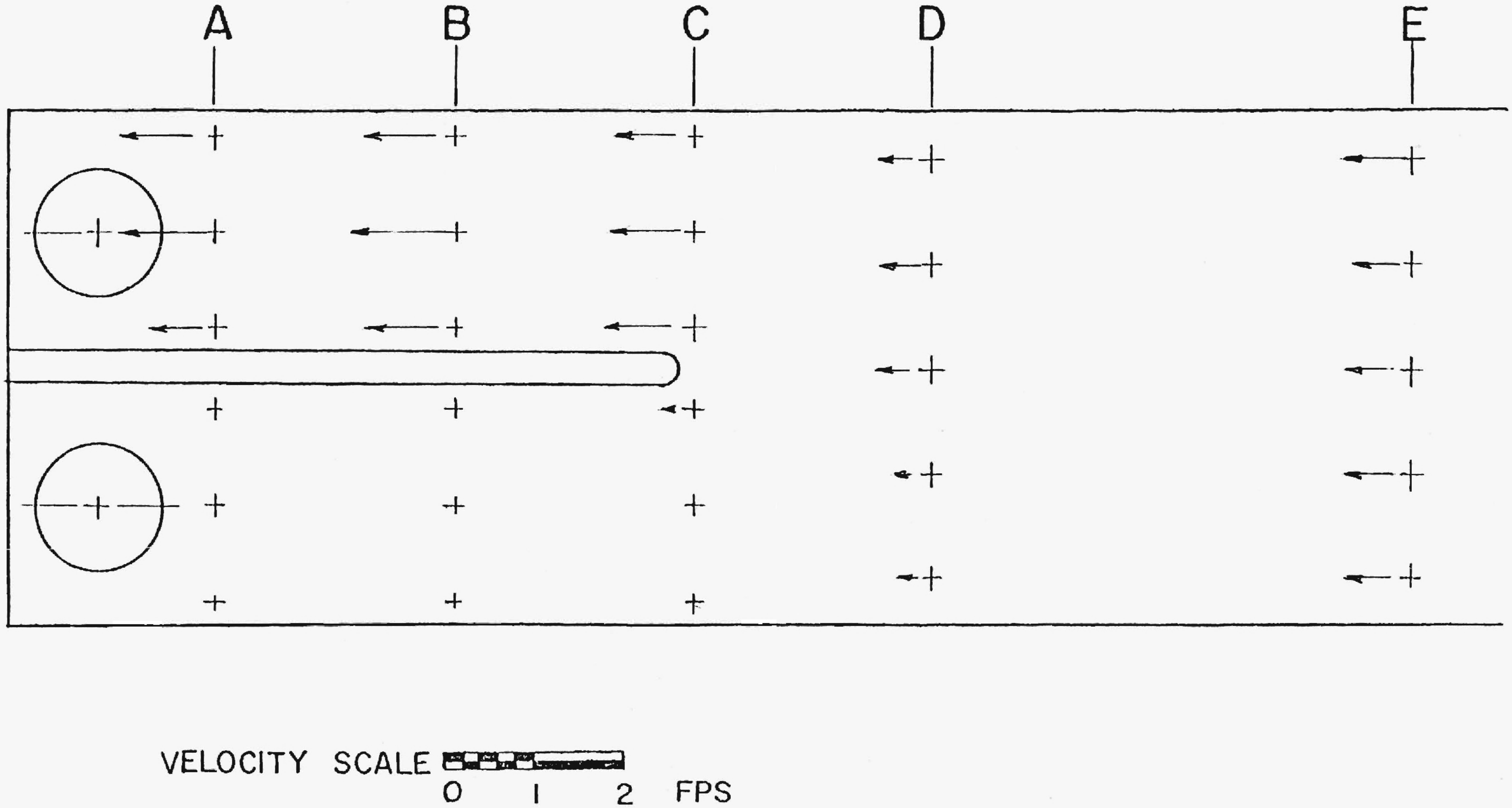


Figure A62. Vogtle IV 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in North Pump Only.

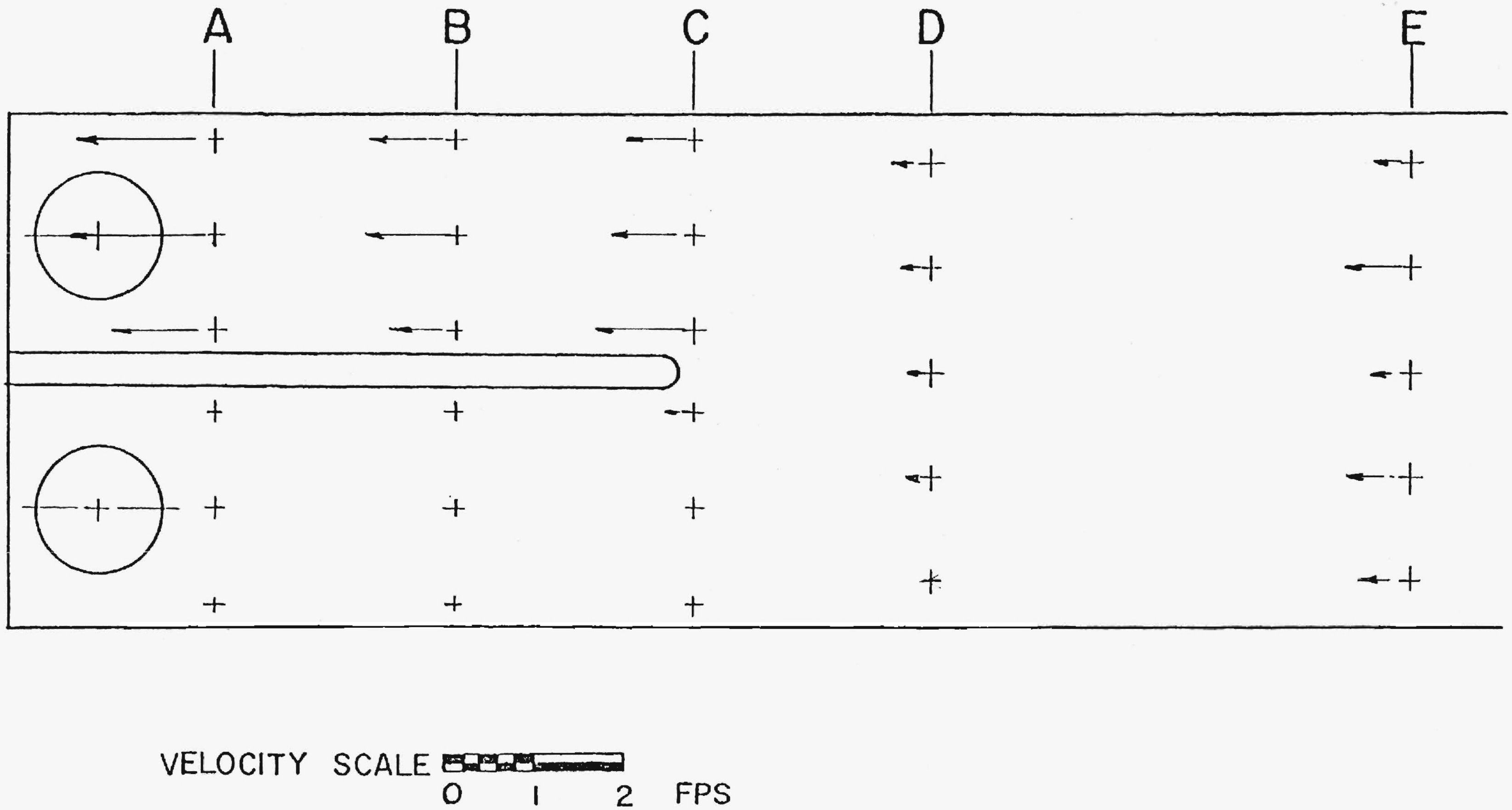


Figure A63. Vogtle IV 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in North Pump Only.

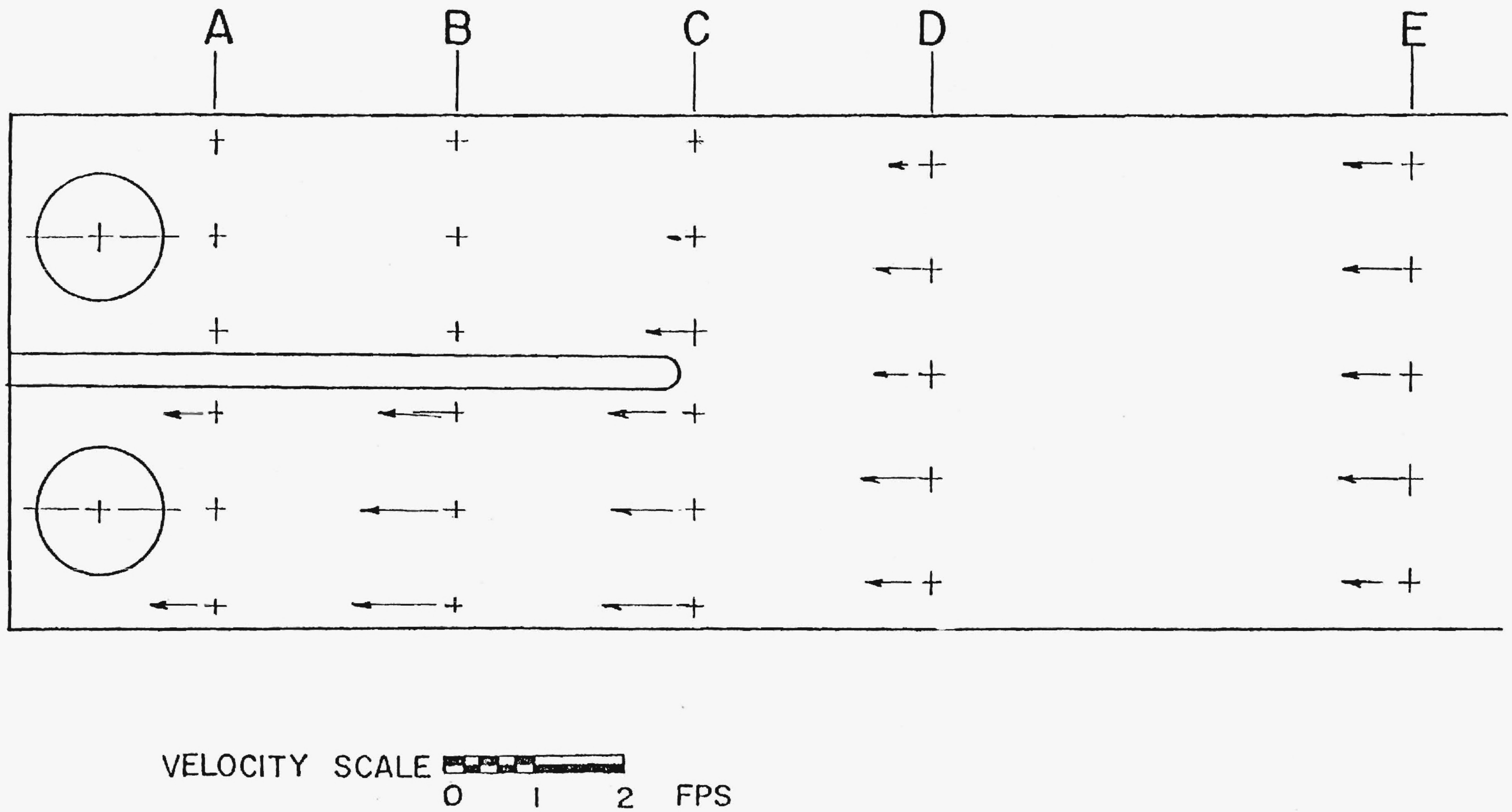


Figure A64. Vogtle IV 1:8 Model, Velocity Vectors 2' Below W. S.
Q = 600 CFS in South Pump Only.

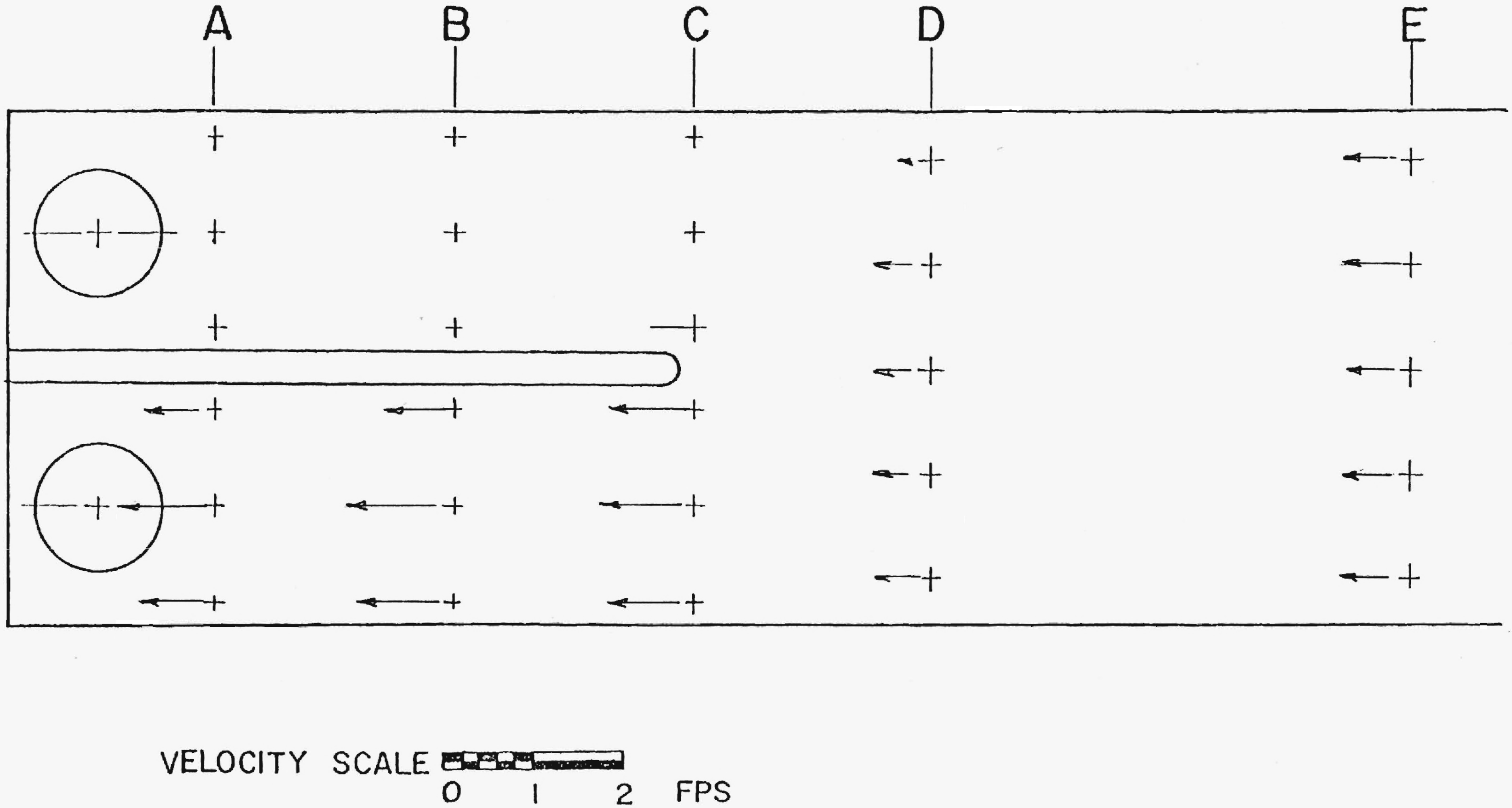


Figure A65. Vogtle IV 1:8 Model, Velocity Vectors at Mid-Depth.
Q = 600 CFS in South Pump Only.

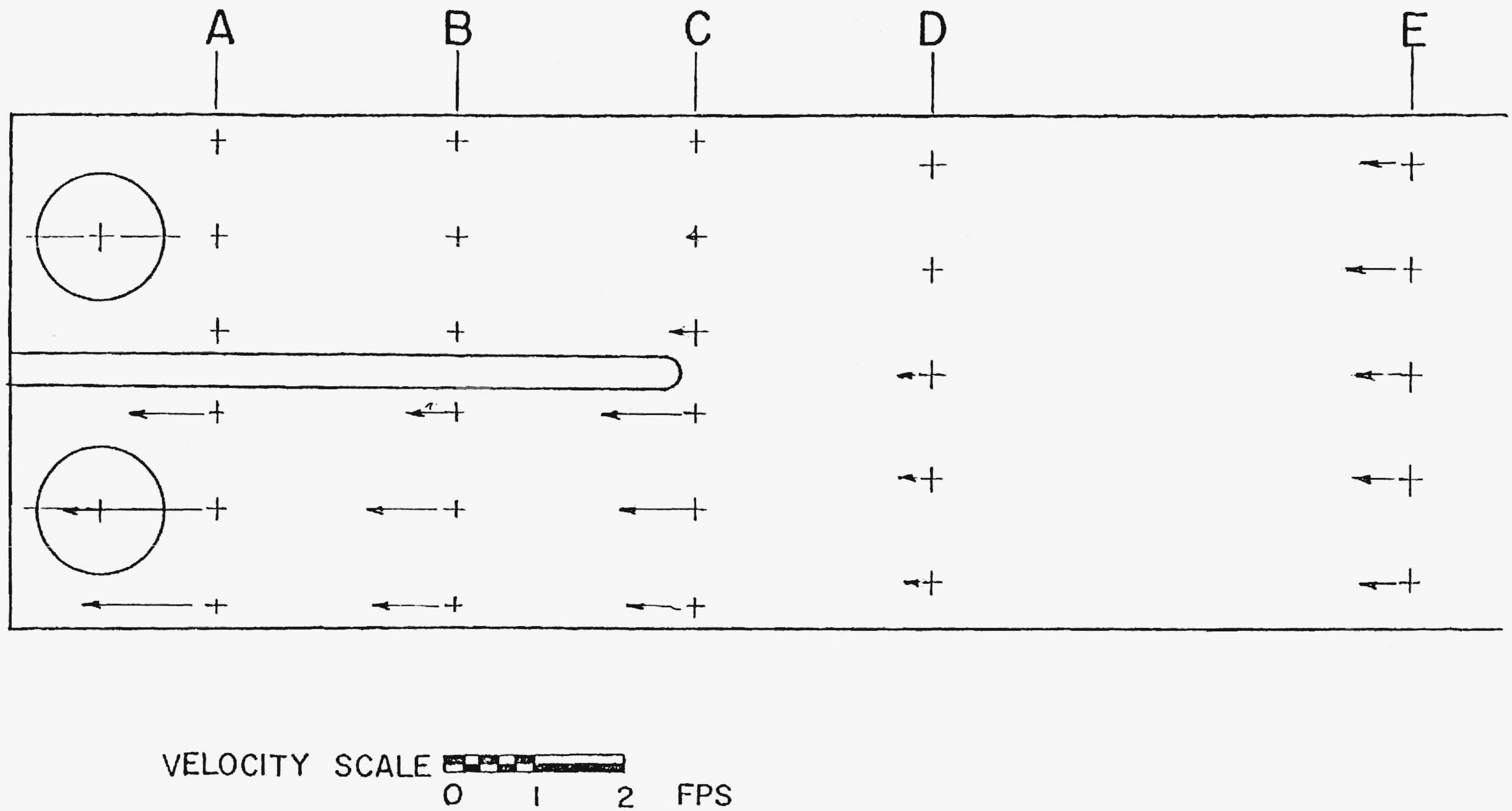


Figure A66. Vogtle IV 1:8 Model, Velocity Vectors 2' Above Floor.
Q = 600 CFS in South Pump Only.